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Cast Iron Axlebox Association.
Institute of British Foundrymen (affiliated).
British Cast Iron Research Association (affiliated).
British Grit Association (affiliated).

Foundry Female Labour

The Council of Ironfoundry Associations has circularised its participating organisations that it is prepared to offer all help possible in the difficult task of extending the use of female labour. This is unquestionably very useful work, as there exists a large body of foundry executives who, following either the fixed policy of the directorate, tradition, or local trade union rules, have never even envisaged the use of female labour. Many firms of American origin are found to enter the first category and, judging from the technical Press of our latest Ally, foundry work is still almost exclusively a man's job. On the other hand, there are a number of British firms which for many years have, with outstanding success, made the fullest use of female labour, and the C.I.A. is the appropriate channel for disseminating the experience so gained. In what follows, we are drawing strictly upon our personal experience and observation. It will seem trite to some readers, and revolutionary to others, and thus depicts truthfully the divergent make-up of the foundry industry. In the course of our visits to works we have seen women functioning as gate and time keepers, charge wheelers, electrode operators, crane drivers, machine moulders, core makers and moulders' labourers. Perhaps the heaviest job is that of charge wheeling, and in this connection it is germane to recall that in the annual report from the chief factory inspector of a few years ago it was stated that it was only very rarely that a woman would attempt to lift a load beyond her strength; this is a contrary phenomenon to boys, who not infrequently rupture themselves by so doing. It is worthy of record that, shortly after the last war, the whole of the staff of a small steel foundry walked out just before the electric furnace was ready to tap. With the help of a young woman as crane driver, the whole floor was successfully cast up. Past issues of the JOURNAL have described how women workers regularly and successfully make cores as large as roll-top desks. The truth is that there are few jobs in a well-organised foundry which women cannot do, provided the skill of the skilled man is utilised where essential. Additionally, we have seen women labour being used in the fettling shop on the lighter type of work. A factor we have also observed is that certain individuals, and especially women, can undertake the dirtiest jobs without becoming particularly dirty. Of a group of half-a-dozen workers engaged on exactly the same job, one will be extremely dirty and one tolerably clean, yet the amount of accumulated facial muck is no index of the amount of work done! In the laboratory, girl labour will be found to be particularly efficient, after a minimum of training, for routine analysis. We realise that a number of managers and owners will still insist that the foundry is no place for women, and our retort is that, if this be so, then there is something wrong with the foundry! The foundry of the future, as there is overwhelming evidence to show, will very nearly approximate the cleanliness and order to be associated with the machine shops. Quite a large number have already attained this standard. The more general introduction of girl labour will have in the long run a beneficial effect on the more backward members of the industry.

An American C.I.A.?

The formation of the Council of Ironfoundry Associations has not only met with the full approbation of the American foundry Press, but so enthusiastic has been the reception of the news that the Editor of "The Foundry" has devoted his leading article in the December issue for the launching of a campaign for the creation of a similar council in the United States. This call is particularly interesting as it comes from the dual position of the Editorial Chair and an important place in the Office of Production Management, the American equivalent of our Ministry of Supply, for Mr. Frank G. Steineback is both an editor and a highly-placed Government official. He has paid us the compliment of quoting at some length from our Editorial commenting upon the formation of the Council, and puts forward as one of the first duties of any American counterpart, the examination of all steel castings to ascertain whether substitution by pearlitic-malleable, malleable or grey iron could not be made. In spite of the fact that more than a dozen steel-foundries are being created in that country, this new capacity added to the million tons per annum output, the production of steel castings is still insufficient. The American foundry industry has indeed a herculean task, for the defence programme—surely this is now archaic and should be renamed "offence"—is involving an annual expenditure of the order of the whole of the accumulated British national debt.

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Workmen's Compensation Scheme

Two new wartime measures have altered the Workmen's Compensation scheme. From January 1, 1942, employers' liability is increased by non-manual workers being included with earnings up to £420 per annum, the limit being raised to that figure from £350, and manual workers being included irrespective of earnings.

The Workmen's Compensation scheme is different from the other Government scheme for unemployment, health and pensions insurance, as under those schemes insurance is compulsory. Under the Workmen's Compensation scheme there is no Government insurance scheme, no payment of contributions, and insurance is not compulsory (except for coal mining), but the liability of the employer to pay compensation is continually present if the event occurs covered by the scheme, to wit, injury by accident or the contracting of an industrial disease.

Compensation may take the form of a lump sum payment, if injury is fatal, payable to dependants, which may amount to £600, or weekly payments, which may amount to 35s. weekly (30s. main scheme, 5s. new Acts), plus, if there is a child or children under 15 years, 4s. for the first two children (or only child), and 3s. for any other child. Weekly payments may continue indefinitely while the disability lasts, but the employer has the right after six months of redeeming these by paying a lump sum, which, if the employee is 21 years of age, and the disability permanent, must be sufficient to purchase a Post Office annuity, equal to three-quarters of the yearly value of the weekly payment; if the employee is under 21 years, the lump sum is fixed by the Court.

If the employer accepts liability, agreements can be made voluntarily between the two parties without recourse to Court action, but all agreements must be registered with the relevant County Court; agreements for the redemption of weekly payments by a lump-sum payment can be made at any time, irrespective of the six months' limit as regards the employer's right; but if the Court considers that the redemption amount agreed upon is inadequate or the agreement has been obtained by improper means, it can refuse registration or make such Order as it thinks fit.

All risks can be covered through ordinary insurance companies, and although, as mentioned, there is no actual Government scheme, there is an arrangement between the Home Office and the Accident Offices Association (most companies are members) whereby premiums are adjusted each year, according to whether the actual Loss Ratio from a yearly balance sheet (loss ratio means the proportion in percentage figures the amount paid in compensation bears to the amount received for premiums) is above or below the basis Loss Ratio of the agreement, now 65 per cent. For current application, accounts show a Loss Ratio of 57.86 per cent., which, set against the basic Loss Ratio, produces a difference of 7.14 per cent., which means that on each premium falling due up to June 30, 1942, there will be a rebate of 7.14 per cent.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Data of Non-Ferrous and Ferrous Metals

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Further to correspondence with you relative to the above, we shall be grateful if you will ask your readers, by the printing of this letter, for the following information:—

What is the weight per cubic inch or cubic foot, both when fluid and when cold, of: (a) Cast iron; (b) cast steel; (c) phosphor bronze; and (d) aluminium and its alloys?

This information does not appear to be printed in any easily available text book, but would obviously be valuable information when designing furnaces, ladles, and ingot or other moulds.—Yours, etc.,

JOHN A. SMEETON.

76, Auckland Road,
London, S.E.19.

Some Jobbing Foundry Experiences—XXXI

By "TRAMP"

Small branch pipes, of which Fig. 1 is typical, are occasionally required from jobbing shops in brass, in the shortest possible time. If a pattern is in existence, the job is simple, but in the majority of cases no pattern is available, and the problem is not so much one of moulding as of quick and cheap patternmaking. The metal thickness of Fig. 1 is ⅛ in., and by ordinary methods fine accurate cutting of the pattern and corebox is necessary to ensure an even metal thickness, operations which are costly in patternmakers' time.

The following method fulfils the conditions and is applicable to a number of jobs. Two pieces of timber are prepared of half the diameter of the large diameter of the pipe bore and dowelled together. The shape of the interior of the pipe is marked on them, an allowance being made for core seats, and the surplus wood removed. These pieces are then worked to form a replica of the core necessary to produce the pipe, with easy curves joining the different diameter. Two frames, as Fig. 2, are made with holes to accommodate a half of the piece previously described as A. Plaster of Paris is then run in these frames, being retained by nails, B, thus forming two half-coreboxes for the production of suitable cores.

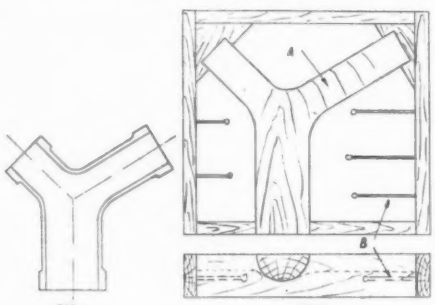

FIG 1 FIG 2

These plaster boxes are varnished and sent to the foundry and a core made and dried while the pattern is completed. This is accomplished by soaking some ⅛-in. leather or similar material in oil so as to make it pliable. This is then fastened on the wood piece, a double row being used at the ends to form the enlarged portion. The pipe can now be moulded and cast with the assurance of even metal thickness.

Notes from the Branches

Falkirk Section.—The December meeting, over which Mr. Thos. Tyrie, B.Sc., presided, was devoted to a lecture, illustrated by lantern slides, on "Blast-Furnace Practice, with Special Reference to the Production of Foundry Irons," by Mr. J. N. Harris. In the short time at his disposal, the lecturer covered the construction of blast furnaces, and the lining, pointing out that 45 per cent. alumina bricks were used in the hearth and a little higher than the top of the bosh. A lower alumina brick is used in the shaft and the throat, and a reinforced, strong, hand-burnt brick in the throat for withstanding abrasion. Charging conditions were fairly fully covered, and specific recommendations were made. Some notes were given of the construction and working of hot blast stoves and the blowing engines. The actual operation of the furnace was fully described, the cleaning of the gas being dealt with in some detail, it being pointed out that modern methods yield a clean-

(Continued in next column.)

Random Shots

The general lack of Christmas cards this year shows how well everybody has responded to the spirit of the times; namely, that of dispensing with all the frills of life so that the energies of the country can be devoted entirely to the war effort. Nevertheless, it was a happy idea of Mr. Gardom's, whilst having to convey to his friends the very necessary information of a change of address, to combine it with the season's greetings. This took the form of a postcard displaying the general geography of his newly-adopted district, with (inevitably) special reference to the position of the many "locals." "Don't get fed up" is the advice he gives, but by the look of the map that seems very improbable, as far as he is concerned, for there appear to be at least a dozen "pubs" within calling distance of his mansion. Even if the beer now has less gravity, one can reasonably hope that it tries to keep a sense of proportion by producing more hilarity.

* * *

The noticeable lack of calendars and diaries is a much more serious affair. It is always difficult to try to make last year's "do." It is all very well for the youngsters to "perquire" one's old diary and assiduously alter all the dates. After all, they would be only too pleased if they could mistake the date of returning to school, even if it were only by one day; but it is a distinct nuisance, after braving the discomforts of a cheerless and foodless wartime journey to the other end of the country, to find that the committee meeting took place the day before. Worse still, if the missed appointment happened to be a select little luncheon party at the Ritz-Savoy!

* * *

An amusing sidelight on the ignorance of the man-in-the-street on matters metallurgical is shown in the following conversation. "It's ruined his business, of course. He had a nice little Continental agency for electric furnaces." "Well, when all's said and done," replied the Ignorant One, "I suppose it was a bit of a luxury trade. In wartime they'll manage with ordinary ones, I expect" !!!

* * *

One cold day, with collar turned up and hands thrust into the pockets of a ragged coat, a little Cockney lad of about seven years of age strode into the public bar. The bar was empty, but, standing on tiptoe to reach the counter, the little fellow banked down his shilling noisily, to attract attention. Presently the landlady arrived and, astonished at seeing so young a customer, said indulgently, "Well, my little man, what can I do for you, to-day?" "A pint uv 'arf-an-'arf" came the ready request.

"I'm sorry, but I can't serve you," said the landlady, politely.

"Well, blinkin' well go and find someone who can!" bellowed the youngster.

* * *

People living in Tokyo Road, Ipswich, are asking the Town Council to give their street another name. This, no doubt, will be followed by a similar request from the residents of Jermyn Street.

"MARKSMAN."

(Continued from previous column.)

liness of 0.015 to 0.020 grms. of dust per cubic metre or a degree equal, or even superior, to the atmosphere of the furnace yard. An interesting point made in connection with iron ore reduction by gas was that between 75 and 90 per cent. is effected, leaving the balance to be effected by the solid carbon of the coke. Reference was made to the recently developed practice of using a CaO + MgO to SiO_2 of 1:1, which involves sulphur reduction by the soda-ash process outside the furnace as an ancillary process.

The Development and Control of Engineering Grey Cast Irons

PART I—PROPERTIES AND CONTROL OF GRAPHITE STRUCTURE

By R. A. FLINN* and D. J. REESE†

Introduction

The purpose of this Paper is to summarise the results of an extended investigation of the properties of grey cast iron, which was begun at the Research Laboratory, International Nickel Company in 1936, and continued at the Massachusetts Institute of Technology, Cambridge, Mass., as a doctorate research problem (Parts 1 and 2).

Whenever a casting fails, whether the failure is the bursting of a pressure vessel, the galling of a lathe-way, the rupture of a tensile specimen in the laboratory, or some other cause, the basic reason for the failure is always the same regardless of the trade name, price of casting or alloy content—the structure was unable to withstand the conditions imposed.

If the properties of a casting be accepted as being dependent entirely on the structure, then to obtain a general knowledge of grey cast iron, it remains only to investigate the structures found in this material and their control. Although examination of the fractured wedge or arbitration bar with the unaided eye has long provided much valuable information on the casting structure, it is necessary in this Paper to add information obtained by closer scrutiny of the structure by using microscopic and atomic methods. For, after all, the actual failure occurs between atoms and groups of atoms which are not observable by the unaided eye.

The structure of grey cast iron may be considered as made up simply of (1) graphite flakes and (2) a ferrous background. The differences in structure are obtained by varying (*a*) shape, (*b*) size, (*c*) amount, and (*d*) distribution of the graphite and the type of background or matrix. The properties and control of graphite structures will be discussed in Part 1 and then the matrix properties and control will be considered in Part 2.

PART I—
PROPERTIES AND CONTROL OF GRAPHITE STRUCTURE

Graphite Shape

The shape of graphite flakes in grey cast iron is predetermined by the interatomic forces which

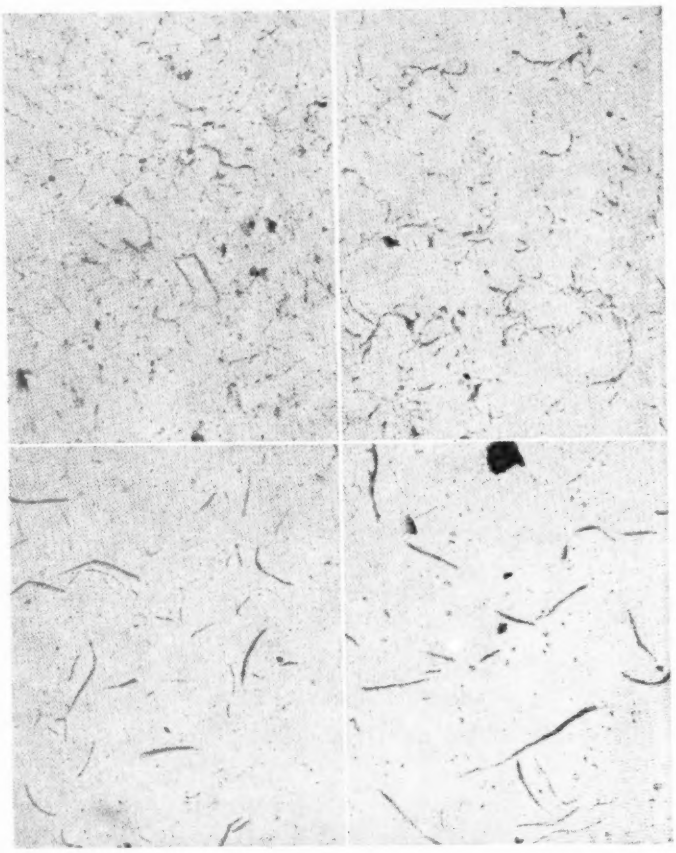

FIG. 1.—INCREASE OF GRAPHITE FLAKE SIZE WITH DECREASE IN COOLING RATE IN AN IRON CONTAINING 2.5 PER CENT. TOTAL CARBON AND 2.5 PER CENT. SI, × 100. (TOP LEFT)—¼-IN. DIA. BAR. (TOP RIGHT)—1-IN. DIA. BAR. (BOTTOM LEFT)—2-IN. DIA. BAR. (BOTTOM RIGHT)—4-IN. DIA. BAR.

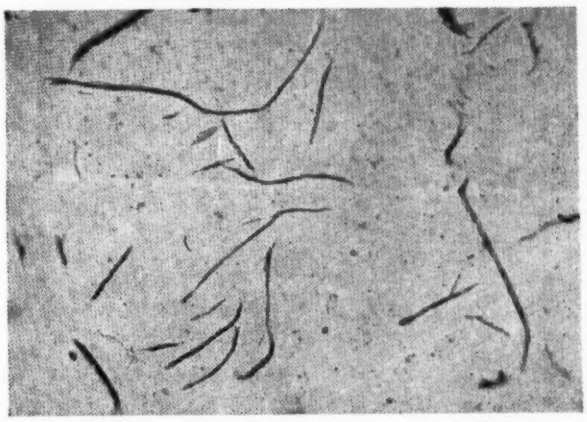

FIG. 2.—FLAKE GRAPHITE IN 4-IN. DIA. BAR OF SAME COMPOSITION AS FIG. 1 BUT WITH 5.0 PER CENT. NI AND 1.0 PER CENT. MO ADDED.

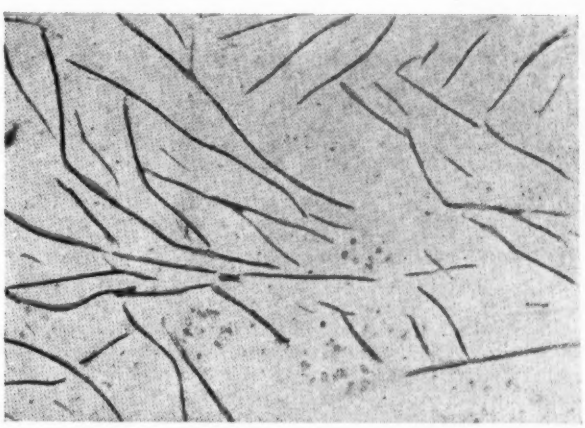

FIG. 3.—MICROGRAPH SHOWING THE INCREASE IN FLAKE SIZE WITH INCREASING CARBON CONTENT. MICROGRAPH OF 2-IN. DIA. BAR CONTAINING 3.5 PER CENT. CARBON AND 1.5 PER CENT. SI. × 100.

Grey cast iron generally is considered a complicated alloy to investigate because of the many elements in its chemical composition. In addition, the wide variety of grey iron applications, and great number of tests used to evaluate the suitability of cast irons for these applications, further complicate a general investigation. It can be demonstrated easily that to prepare a series of irons of all important combinations of carbon, silicon, manganese, phosphorus and sulphur would require over a half-million heats, and literally millions of tests would be needed to investigate the engineering properties of these irons. Even with this colossal amount of work, the effects of alloying elements, and of variations in metal processing and handling, would still remain to be studied. The present research is based on a far simpler, yet more comprehensive, approach.

predominate under the conditions of its formation. In other words, at the time of solidification or later, the graphite crystallises in the form of flat plates which, due to their low strength, are badly distorted by the stronger matrix which is forming from the liquid at the same time. These badly distorted hexagons are the familiar graphite flakes seen in cross-section under the microscope. When graphite is formed at high temperatures (1,040 to 1,150 deg. C.), this flake shape is to be expected, and no known attempts to produce grey cast iron containing the nodular type graphite or temper carbon of malleable iron have proved successful. The

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Engineering Grey Cast Irons

nodular type graphite is formed when the iron carbide of white iron is reheated to about 926 deg. C., and, due to difficulty of flat hexagonal crystal growth at these temperatures, the temper carbon spheroids are formed by plating carbon atoms uniformly on to a nucleus.

Although the graphite structure of malleable iron produces superior ductility, grey iron possesses better casting characteristics, due to the expansion which accompanies graphitisation on solidifying. The flat graphite flakes also produce higher damping capacity. In the past, practically every alloying element has been advocated, in turn, as a means of changing graphite shape. These claims are gradually being abandoned or modified as the mechanism of graphitisation becomes better known.

Graphite Flake Size

Graphite flake size has received a great amount of attention in the past and, as with graphite flake shape, the effect of most alloys on flake size has been overstressed. The most important factors in determining graphite flake size are, in order: the section size (cooling rate) of the casting, the amount of carbon, and other factors affecting the tendency of the iron to graphitise. If the total and combined carbon contents are kept constant, section size becomes the most important factor in determining graphite flake size. Figs. 1 and 2 show the increase in graphite flake size as cooling rate at time of graphite formation is lowered. (Section size increased.) This phenomenon is merely another manifestation of the general principles of crystal growth; larger crystals being formed with decreased cooling rate. The addition of alloying elements is seen to have relatively little effect as the 5 per cent. nickel-1 per cent. molybdenum iron shows the same flake size when poured under identical conditions into a similar mould.

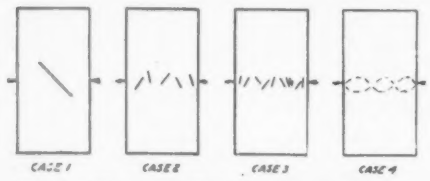

FIG. 4.—EFFECT OF GRAPHITE FLAKE SIZE AND DISTRIBUTION. DISTRIBUTIONS OF THE TYPES INDICATED IN CASES 1, 2 AND 3 PRODUCE HIGHER STRENGTHS THAN A DISTRIBUTION AS IN CASE 4.

The effect of increasing carbon content is demonstrated by Fig 3. As the carbon content is increased, the amount of carbon available for flake growth is increased and larger flakes are found, culminating in the very large flakes of 4 per cent. carbon pig-iron. Graphite flake size will be considered again in the section under distribution.

Before concluding this section, however, the change in properties with flake size should be discussed briefly. It is more tradition than fact that by increasing graphite flake size, tensile strength, transverse strength and other physical properties are markedly lowered. In Fig. 4, an illustration of this effect is shown. If the ferrous background is kept contant in cases 1, 2 and 3, the effect on strength of dispersing a given amount of unaffected matrix is the same. The folly of sacrificing random graphite distribution for the sake of slightly smaller flakes poorly distributed, is shown in case 4. This will be covered under "Distribution."

There is, however, a great mass of evidence which shows undeniably that specimens with large graphite flakes show poorer strength than specimens with smaller graphite flakes—graphite distribution remaining constant. This is because the graphite flakes are merely indicators of the crystal size and cooling rate of the background material with the same carbon content, and due to the slower cooling rate, the background material of the specimen of the unalloyed irons of Fig. 1 coarsens as the graphite flake size increases (Fig. 5). The larger grain size, lower combined carbon and coarser carbide particles are responsible mostly for the decrease in physical properties associated with large graphite flakes.

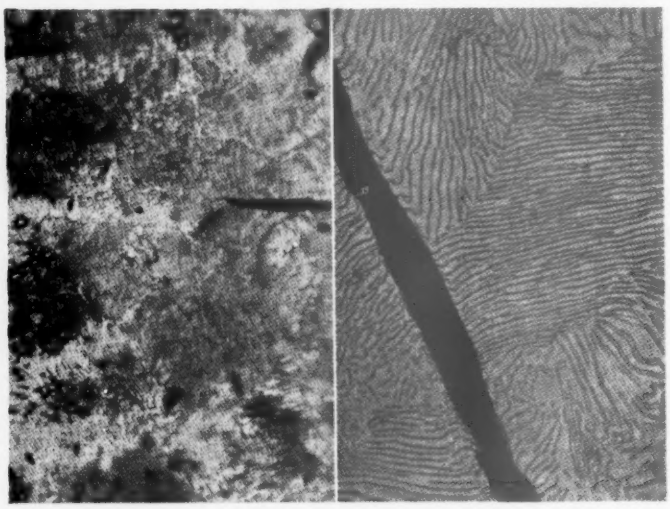

FIG. 5.—IRON OF FIG. 1, ETCHED WITH 2 PER CENT. NITAL, × 1,500. (LEFT)—FINE PEARLITE AND GRAPHITE. (RIGHT)—COARSE PEARLITE AND GRAPHITE. ILLUSTRATING THE ASSOCIATION OF FINE GRAPHITE WITH FINE PEARLITE AND COARSE GRAPHITE WITH COARSE PEARLITE.

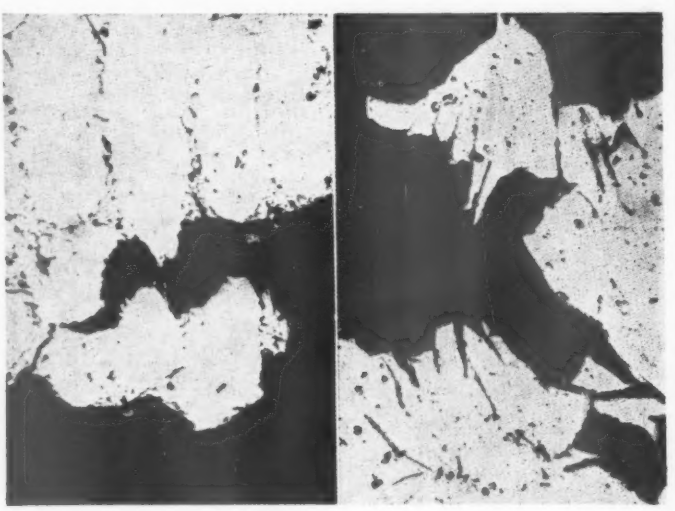

FIG. 6.—ILLUSTRATING VARIATIONS IN PROPERTIES OF CASTINGS DUE TO GRAPHITE DISTRIBUTION. (LEFT)—GRAIN-BOUNDARY TYPE WHICH FORMS A CHAIN OF WEAKNESS PRODUCING LOW STRENGTHS, POOR WEAR RESISTANCE, AND UNEVEN MACHINABILITY. (RIGHT)—STRUCTURE SHOWING RANDOMLY-DISTRIBUTED GRAPHITE CONDUCIVE TO HIGHER PHYSICAL PROPERTIES.

TABLE I.—*Effect of Decreasing Carbon Content on Tensile Strength and Brinell Hardness of Cast Iron Holding Combined Carbon Constant.*

T.C per cent.	C.C per cent.	Si per cent.	Mn per cent.	P per cent.	S per cent.	A.S.T.M. Type B Bars.*			
						Transverse strength, lb.	B.H.N.	Tensile strength, lb. per sq. in.	Per cent. graphite.
3.25	0.75	1.82	0.91	0.12	0.10	2,700	232	42,500	2.50
3.09	0.81	1.77	0.85	0.13	0.08	2,850	228	47,000	2.28
2.82	0.85	2.02	0.84	0.13	0.08	3,210	242	55,200	1.97
2.51	0.81	2.53	0.84	0.12	0.09	3,620	255	60,200	1.70
2.38	0.87	2.40	0.84	0.05	0.03	3,810	277	65,100	1.51

* All matrices pearlitic; all graphite in random distribution, some flake shape. Bars poured 165 deg. C. above quidus, in dry sand moulds.

Effect of Amount of Graphite

The foundryman long has appreciated the beneficial effect of lowering carbon content on physical properties by adding steel scrap to the cupola charge. He has conveyed the importance of this lowered carbon content by imply-

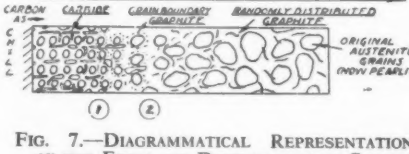

FIG. 7.—DIAGRAMMATICAL REPRESENTATION OF THE FORM AND DISTRIBUTION OF CARBON IN VARIOUS SECTION SIZES OF AN IRON CONTAINING 2.50 PER CENT. TOTAL CARBON, 2.50 PER CENT. SI, 0.80 PER CENT. MN, MELTED BELOW 1,537 DEG. C. AND POURED AT 1,426 DEG. C. THE AUSTENITE PORTION OF THE EUTECTIC IS NOT SHOWN.

ing a closer approach to the tensile strength of steel by calling the product "semi-steel." The addition of steel to the cupola charge does not necessarily improve physical properties, and only rarely is the steel in the charge used to full advantage. The purpose of this section is to discuss in detail the effect of amount of graphite, which is lowered as the total carbon is lowered.

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provided the amount of carbon in the matrix (combined carbon) remains the same.

Most grey cast iron contains a total carbon content of from 2.2 to 4.0 per cent. If, in this range of carbon contents, the matrix be kept the same, as pearlite for example, then about 0.80 per cent. combined carbon will be present, leaving the range of graphitic carbon as 1.4 to 3.2 per cent. Since graphite is over three times lighter than the ferrous background, if 1.4 to 3.2 per cent. graphite is present by weight, then 4.6 to 10.3 per cent. is present by volume. Since the volume, and not weight, of graphite determines its effect on strength and most other mechanical properties, the effect of lowering carbon content is seen to be considerable. Due to the flake shape of graphite in cast iron, the effect of a given amount is multiplied several fold. From Table I it is evident that if graphite amount is the only factor changed, the tensile and transverse strengths are raised markedly as carbon content is lowered.

On the other hand, if optimum machinability is desired, a graphitic carbon content of about 2.20 to 2.50 per cent. by weight or a total carbon of 3.00 to 3.30 per cent. by weight is desirable. In metal moulds subjected to intense stresses, as in glass, ingot and permanent cast-iron moulds, a still higher amount of graphite is desired to cushion the rapid expansion of the ferrous background. For maximum wear resistance, a carbon content in the range of 2.8 to 3.2 per cent. is desirable, since extremely low-carbon irons do not contain enough graphite, while high-carbon irons have low surface strengths. The damping capacity of high-carbon iron is greater than that of low-carbon iron, while both are many times higher than steel. This capacity to absorb or dampen vibrations is due to the graphite, and is an important advantage of cast-iron machine bases and other machine tool parts over welded steel construction and of cast-iron crankshafts over steel crankshafts.

Graphite Distribution

The control of graphite distribution is one of the simplest yet most effective methods at the disposal of the foundryman for producing superior grey iron castings. Fig. 6 shows the variations in properties of castings which are possible due to change in graphite distribution alone. Composition, pouring temperature and mould conditions were kept constant. In the case of the structure in Fig. 6 (left), where the graphite is in a grain boundary* type of distribution and forms a chain of weakness across the bar, low strengths, poor wear resistance, and uneven machinability are obtained.

When, however, the graphite is in good distribution (randomly distributed), the fracture occurs through an area of graphite only proportional to the amount present, and therefore includes a lesser amount than in Fig. 6 (left). Higher physical properties are therefore obtained, since the strength of graphite is very low compared to any ferrous background. As mentioned under the heading "Graphite Flake Size," and illustrated diagrammatically in Case 4, Fig. 4, random graphite distribution should not be sacrificed to obtain finer flake size. Although Fig. 6 (left) shows finer graphite, the faulty distribution far overshadows any slight advantage which may have been obtained.

* In this Paper the term "Grain boundary graphite" will be used to describe the type of graphite shown in Fig. 6, left. This term has been suggested by Earnshaw Cook, in place of other terms previously used (dendritic, eutectiform). Since this type of graphite delineates the grain boundaries of the primary austenite dendrites, it is not itself "dendritic." The word eutectiform is vague and confusing due to the many known forms of eutectic structure.

Since the importance of graphite distribution has been indicated, the reasons for differences in distribution may now be considered and methods of control discussed.

Reasons for Different Types of Graphite Distribution

If a heat of cast iron of 2.50 per cent. total carbon, 2.50 per cent. silicon, 0.80 per cent. manganese is melted at below 1,537 deg. C. and poured at 1,426 deg. C. in various diameter castings, the form and distribution of carbon will be as shown diagrammatically in Fig. 7. In thin sections, white irons are obtained, and in heavier sections grey irons are encountered. In the heavy sections the iron cools under more nearly equilibrium conditions and the stable graphite is formed. In light sections the iron passes quickly through the high-temperature range where iron-carbide decomposition is rapid and remains carbidic (white).

The facts of the preceding paragraph are, of course, well known, and were introduced only to show the true relationship of the grain boundary type of graphite to carbide and randomly-distributed flake graphite. It is proposed that the grain boundary type of graphite is formed from eutectic cementite at temperatures below the eutectic, while the well-distributed, larger-flake graphite is formed at the eutectic.

The most direct evidence for this mechanism was obtained by quenching bars in which different types of graphitisation were occurring at and below eutectic temperatures (as determined by imbedded thermocouples). In bars in which well-distributed, medium-size graphite flakes were found, the graphite grew at eutectic temperature with comparative freedom. However, bars which would show grain boundary graphite, if sand cooled, were found to solidify

TABLE II.—*Properties of Inoculated Irons.*

Heat No.	Ladle Inoculant.	Per cent. of Element Added.	Per cent. Total Addition.	Analysis.* T.C per cent.	Analysis.* Si per cent.	Transverse‡ Strength, Lb.	Deflection, In.	Tensile Strength,† Tons per sq. in. 1.	2.	3.	BHN	
T-11678	85 per cent. Fe-Si	0.50 Si	0.59	2.40	2.28	3,200	0.24	26.2	27.0	26.3	255	GROUP A. Fine grained, light grey, equiaxed, random graphite distribution.
T-11679	97 per cent. Fe-Si	0.50 Si	0.52	2.51	2.36	3,200	0.24	25.0	24.6	22.3	255	
T-11680§	Graphidox No. 1	0.05 Si	0.20	2.51	2.39	2,900	0.21	23.1	23.5	22.6	245	
T-11681	Do.	0.15 Si	0.60	2.49	2.49	3,200	0.25	24.6	25.4	27.0	248	
T-11692	Alloy C	0.75 Si	1.08	2.40	2.50	3,600	0.23	26.8	28.2	23.6	269	
T-11693	Do.	0.50 Si	0.72	2.40	2.50	3,300	0.23	26.1	23.7	24.2	269	
T-11676	"A" Ni Shot	0.50 Ni	0.50	2.54	2.35	2,600	0.20	21.5	18.2	18.2	252	GROUP B Black, dendritic fracture due to graphite distribution (grain boundary type).
T-11677	Do.	0.50 Ni	0.50	2.40	2.27	2,300	0.16	18.2	18.5	18.7	254	
T-11682	H.L.H.	—	1.0	2.47	2.46	2,500	0.17	21.8	21.6	21.4	277	
T-11683	Ni-Ti-Si	—	0.40	2.43	2.49	2,400	0.16	20.6	19.6	18.3	254	
T-11684	Ni-Mg	0.10 Mg	0.12	2.43	2.34	2,300	0.15	17.9	18.3	19.2	244	
T-11642	Ni-Si	0.50 Si	1.05	2.33	3.08	2,300	0.14	18.7	19.9	21.0	269	
T-11646	Ni-Si	1.00 Ni	2.10	2.55	3.07	2,600	0.14	18.6	19.1	18.8	269	
T-11663	Ni-Si-Al(1 per cent.)	0.45 Si	1.13	2.67	2.57	2,600	0.17	21.7	21.6	19.6	274	
T-11665	Ni-Si-Al(2 per cent.)	0.37 Si.	0.98	2.64	2.51	2,700	0.19	21.4	20.3	21.6	274	
T-11673	Ni-Si-Al-Mn	—	1.04	2.68	2.51	2,700	0.16	22.0	21.8	21.8	269	
T-11617	Graphite + Fe-Si	0.55 Si + 0.15 C	0.80	2.41	2.85	2,100	0.15	20.1	19.5	18.3	235	
T-11655	None	—	—	2.66	2.99	2,300	0.15	17.4	19.4	18.6	254	

* Mn, 0.90–1.0 per cent.; P and S, 0.10–0.15 per cent.
† Pouring temperatures; Bar 1—1,537 deg. C.; Bar 2—1,500 deg. C.; Bar 3—1,455 deg. C.
‡ 18-in. span, 1.21-in. diameter bar—Average of 3 bars.
§ Final Analysis: Al, 0.07; Ti, 0.10 per cent.

Chemical Composition of Inoculants

Inoculant.	Analysis, per cent. Si	Mn	Al	Ti	Mg	Ni	Mo	Cr	Fe	C	
85 per cent. Fe-Si	86.10	—	1.00	—	—	—	—	—	Bal.	—	GROUP A
97 per cent. Fe-Si	97.20	—	0.15	—	—	—	—	—	Bal.	—	
Graphidox No. 1	25.00	—	14.49	7.00	—	—	—	—	Bal.	2.00	
Alloy C	70.00	10.00	1.64	0.10	—	—	—	—	Bal.	—	
"A" Ni Shot	0.35	—	1.93	—	—	97.43	—	—	0.34	1.60	GROUP B
Ni-Ti-Si	25.00	—	—	25.00	—	50.00	—	—	—	—	
Ni-Mg	—	—	—	—	68.50	31.50	—	—	—	—	
H.L.H. (1)	—	—	—	—	—	25.00	25.00	12.00	Bal.	2.00	
Ni-Si	50.30	0.02	0.04	—	—	47.70	—	—	1.45	—	
Ni-Si-Al (1 per cent.)	39.98	—	1.01	—	—	56.52	—	—	Bal.	—	
Ni-Si-Al (2 per cent.)	43.74	—	2.06	—	—	52.28	—	—	Bal.	—	
Ni-Si-Al-Mn	42.76	14.24	0.97	—	—	40.11	—	—	Bal.	—	

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as white iron and then graphitise on cooling. The sections which were white as-cast, of course, cooled through the sub-eutectic graphitisation range with sufficient speed to avoid breakdown of carbide.

Further evidence is obtained from irons cast against a chill. Fig. 7 shows clearly the relationship of the grain boundary graphite to the carbide. Next to the chill, fast cooling rates are prevalent and white iron is obtained. The metal just next to the carbide also freezes as white iron, but the cooling rate is slow enough to cause graphitisation. This graphite forms in place by the reaction:

Iron carbide decomposes to iron and graphite

$$Fe_3C = 3Fe + C \text{ (graphite)}.$$

(It is to be noted that this reaction also gives the key to the formation of free ferrite (low-carbon iron).) The metal farther back is not affected by the chill and comparatively larger, well-distributed graphite flakes form freely at the slower cooling rate.

In addition, irons which show grain boundary graphite exhibit lower temperatures (11 to 33 deg. C.), on freezing, than irons with randomly distributed graphite. This fact offers additional evidence for the statement that the grain-boundary-graphite irons freeze as austenite + iron carbide, while the irons with randomly distributed graphite freeze as austenite + graphite.

The Control of Graphite Distribution

A lengthy account has been given of the reasons for different types of graphite distribution to permit the reader to realise the general method underlying the system of graphite control to be discussed. Obviously, the foundryman cannot always pour his castings in heavy sections so as to obtain well-distributed graphite flakes. What is needed to decrease the tendency of the iron carbide—iron eutectic to form and increase the tendency of graphite to form at the eutectic? Silicon has long been used to reduce chill and, in other words, to promote carbide decomposition. If the silicon be raised to a high level (4 to 5 per cent.), little grain boundary graphite is obtained in medium sections, but the resulting iron is soft and weak. (This is due to the additional effect of the silicon on the matrix to be discussed in Part 2.) The same effect can be obtained in the 1.5 to 2.5 per cent. silicon iron if 0.50 per cent. be added to the ladle just before pouring. The effect of this addition passes away with time (about 20 mins.) and therefore appears to be due to high silicon spots, which promote the formation of an iron graphite eutectic and possibly small amounts of proeutectic graphite.

Table II gives the results of various ladle additions. The most important point to notice is that all successful ladle additions, that is, those which give random graphite distribution and therefore high tensile strength, contain silicon. Some unsuccessful inoculants contain silicon, but in these cases it was noticed that the material was dissolved by the melt much more easily than ferro-silicon. It is of academic interest that graphite was found successful only when added to the arbitration bar mould as the stream of metal entered. In this way, the graphite probably was not dissolved completely before solidification, so that it could act to promote the iron graphite eutectic. The successful addition of small amounts of silicon carbide may be ascribed to the difficult solution and refractoriness, and consequence persistence of these particles in the melt.

The effect of other influences on graphite formation also may be clarified by the above picture of graphitisation. Since superheating increase carbide stability, as indicated roughly

(Continued in last column.)

Present Apprentice Systems Criticised

A complete scheme for the reorganisation of the apprentice system to the engineering trades, which he called at present "inefficient and hopelessly inadequate," was described by Mr. W. S. Cormack, Principal of Stow College, Glasgow, addressing the Fabian Society on "Training for Industry Post-War Reconstruction." The apprentice was more or less left haphazardly to pick up any knowledge of the trade which he was supposed to be learning, or with the dubious help of a journeyman who had never himself been taught the best way of doing the job. Lines of demarcation hampered him everywhere. A patternmaker must not do the work of a moulder, though both trades were much akin. If apprenticeship were to survive and trade to flourish, much of these lines of demarcation must be abandoned.

The only scheme which could be envisaged was a return to the original conception of apprenticeship as an all-round training designed and supervised throughout to produce competent craftsmen. Justice to the rising generation insisted that old obsolete and disorganised systems of industrial training should be overhauled. Apprenticeship was a period of post-school training, and he suggested that a committee consisting of representatives from the Ministry of Labour, employers' associations, trade unions, education departments, etc., should map out a scheme of training providing an efficient worker at the end of his five years of training with a certificate of competency, just as a university graduate took his degree.

He challenged the trade unions for their lack of interest in the training of future members and considerations of their qualifications for admission, contrasting the more careful selective principles of the professional organisations in this direction. He thought little support for such a reorganisation could be expected from the trade unions. While these unions have given enthusiasm for ideas which were revolutionary in the end of the 19th century, but which were now almost reactionary, he accused them of fostering, if not actually imposing, the limitations which prevented an apprentice from learning certain aspects of his trade, and thus prevented him from becoming a good craftsman.

The Cost of War

The financial cost of the war is reflected in the growth of the public debt totals of the principal countries concerned. From June, 1939, the total public debt of the United Kingdom has increased from £7,284 million to £11,551 million at the end of August last. The public debt of Holland has risen from 758 million fl. in June, 1939, to 2,154 million fl. in July last, and that of Belgium from 37,640 million fr. at the end of 1938 to 58,004 million in March last. The public debt of the United States was $40,439 million in June, 1939, and $50,921 million at the end of August last. It is now stated that war expenditure in the United States will in the 1943 fiscal year amount to half the national income, *i.e.*, equivalent to about the level of the British national debt in August last. In the Reich, the debt figure was 33,259 million Rmk. in June, 1939, and about 100,000 million Rmk. in June last, when the floating debt slightly exceeded the consolidated debt, while in 1939 less than 10,000 million Rmk. was floating. In Japan, public debt increased from 17,647 million yen in June, 1939, to 29,658 million in March last, since when there has been a further increase. Bulgaria has nearly doubled her debt in two years, from 8,805 million lev in June, 1939, to 15,633 million in July last, while her external debt has decreased slightly, from 12,946 million to 12,608 million, in the same period. Two-thirds of the total internal debt is floating. Sweden, a neutral, has also been seriously affected, her total internal and external debt in June, 1939, being 2,634 million kr. and in August last 5,601 million. Unless otherwise stated, the debt figures given apply to internal debt only.

Films for Training Steelworkers

Motion pictures produced by the United States Steel Corporation and its subsidiary companies are proving valuable in training workers for national defence jobs. Each month more than 3,000 men in classrooms, factories, and arsenals see the details of steelmaking through the films. "The Making and Shaping of Steel" is the latest film released.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

540,011 LESTER, N., and LESTER ENGINEERING COMPANY. Pressure casting machines.

540,039 MOND NICKEL COMPANY, LIMITED. Nickel alloys.

540,043 UDY, M. J. Chromium metallurgy.

540,048 GLACIER METAL COMPANY, LIMITED, HOLLIGAN, P. T., and BATE,, J. Coating of relatively strong metals or alloys of high melting point with other metals or alloys.

540,078 BRIDGES, W., and CHAMBERS, A. J. Hardening and tempering of projectiles.

540,094 DETRICK COMPANY, M. H. Furnace walls and methods of constructing the same.

540,105 STERN, M. Briquetting or ingoting scrap of light metals or alloys.

540,182 LUCAS, A. R., and LUCAS, L. R. J. Refractory material, such as high-temperature insulation bricks for furnace linings and the like.

540,228 CONSOLIDATED MINING & SMELTING COMPANY OF CANADA, LIMITED. Addition agents for manganese electrolytes.

540,229-30-31 STANTON IRONWOKS COMPANY, LIMITED, and WILSON, P. H. Casting of metals.

540,243 JONES & LAUGHLIN STEEL CORPORATION. Controlling Bessemer converters.

540,249 DIGBY, W. P., and DIGBY, E. T. Casting copper chromium steels.

540,270 POKORNY, E. A. Hard facing of metals.

540,276 JACQUET, M. V. M. (Jacquet, J. F. A.). Process and device for the continuous casting of small-section ingots without surface depressions.

540,286 LESTER, N., and LESTER ENGINEERING COMPANY. Casting machines.

540,565 HAYNES STELLITE COMPANY. Method of making composite metallic articles.

540,601 POTTS, H. E. (Electro Metallurgical Company). Alloy steels.

540,637 JUNGBLUT, C., and SOC. ANON. DES HAUTS FOURNEAUX ET FONDERIES DE PONT A MOUSSON. Machine for the internal coating of pipes.

540,708 BRITISH THOMSON-HOUSTON COMPANY, LIMITED. Method and apparatus for casting permanent magnets.

540,357 MOND NICKEL COMPANY, LIMITED. Nickel-iron alloys.

540,426 GREENIDGE, C. T. Method of continuous metal casting.

540,483 LESTER ENGINEERING COMPANY. Pressure casting machines.

540,744 FORD MOTOR COMPANY, LIMITED (Ford Motor Company). Cupola type furnace construction.

540,795. PFEIL, L. B. Heat-treatment of metal alloys.

541,077 BRASSERT & COMPANY, LIMITED, H. A. Method of operating a shaft furnace.

541,122 CRADICK, M. J., DUNTON, A. R., and METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED. Method of and apparatus for determining the surface hardness or resistance to scratching of smooth or polished surfaces of materials, or of coated objects or materials.

541,147 LANCASHIRE METAL SUBLIMING CORPORATION, LIMITED, and HAMILTON, W. B. Induction furnaces.

(Continued from first column.)

by increased chill depth, the fine, grain-boundary type graphite would be expected in irons heated to over 1,537 deg. C. for appreciable periods of time. This was corroborated by many heats and often is shown in the literature. However, the physical properties of superheated irons, cast without further treatment, were found to be consistently below either superheated or normally heated (1,482 deg. C.) irons which were treated with ladle additions. This is not always confirmed by the literature, in which small increases in strength are claimed as due to superheating, while cold pouring temperatures for unsuperheated comparison bars may often give irregular results.

(To be continued.)

Requisite Characteristics of Blast-Furnace Coke

REVIEW OF VARIOUS ASPECTS OF THE FUNCTIONS OF COKE IN THE BLAST FURNACE

The principal function of coke in a furnace is to act as fuel, being burned to supply heat for the reduction and melting of iron; nevertheless, the correct evaluation of blast-furnace coke is still an unsolved problem. Most blast-furnace managers would assess the value of a coke by charging it into a blast furnace and observing the operation. M. A. MAYERS, of the Carnegie Institute of Technology, considers that results of measured blast-furnace performance must be used to assess the value of coke. Before the Blast Furnace Committee of the American Institute of Mining and Metallurgical Engineers, he has already described a method, involving the use of mathematical statistics, which can evaluate separately the various factors that affect blast-furnace operation, so that the influence of the coke can be determined.

In a further Paper read at a meeting of the Eastern States Blast Furnace and Coke Oven Association on June 6, he examines present knowledge of these data. It has long been believed that the temperature in the crucible of a blast furnace depends on the temperature attained due to combustion at the tuyeres. For this reason, blast-furnace operators have called for a highly reactive coke in the belief that such a coke would burn more rapidly to produce a higher temperature than a less reactive one. This idea is, however, probably erroneous.

Reactivity of Coke

In the first place, the maximum temperature attained anywhere in the combustion zone decreases with increased reactivity of the coke, other things being equal. This occurs because the speed of the heat producing reaction resulting in the formation of CO_2 is so fast that its speed is determined only by the velocity of the blast and is nearly independent of the reactivity of the coke; while the heat absorbing reaction, resulting in the formation of CO, is slow enough so that its speed can be increased by increased reactivity. Thus, an increase in reactivity leads to an increased rate of heat absorption for the formation of CO, thus decreasing the maximum temperature produced. This effect, incidentally, is important in cupolas, in which unreactive coke, for the production of maximum melting temperatures, is desired.

In the Coal Research Laboratory of the Carnegie Institute a test for reactivity has been developed with which the characteristic rates of reaction of various fuels can be readily determined. The test is a development from the usual ignition temperature measurement, but is unique in that an observation in addition to that of the so-called ignition point permits the determination of reaction rates. By the use of this device the reactivities of a number of blast-furnace cokes, classified as good or poor by the operators, were determined. There was no consistent relation between the reactivity of the coke and its classification by the operators.

Consumption of Air Gases

Finally, in the blast furnace all the air for combustion is consumed with the production of carbon monoxide within a short distance from the tuyeres compared to the hearth diameter and the distance from the tuyeres to the level of the bath. Kinney, Perrott, Sherman and others have shown beyond doubt that no oxygen remains in the blast beyond about 30 in. from the nose of the tuyere, and that the carbon dioxide is completely reduced to monoxide beyond about 48 in. Hence, only the heat of combustion to carbon monoxide can be available at any point beyond this zone; and this is constant and entirely independent of the reactivity of the coke. Thus, it would be expected that the temperature of combustion is relatively constant, regardless of coke properties.

This does not imply, however, that the temperature distribution below the mantle is independent of coke properties or the operation of the furnace. The temperature distribution is determined by the ratio of the heat capacity of the stock flowing down through the furnace to that of the bosh gas flowing up. While the actual furnace is too complicated for an exact solution, the example shown in Fig. 1 indicates what may be expected. When the heat capacities of stock and air are equal as in Fig. 1b, the temperature falls off linearly from its value at the end of the combustion zone; if the heat capacity of the stock flow is less than that of the gas as in Fig. 1a, the curve of temperature is concave downward; while if it is greater than that of the gas as in Fig. 1c, it is concave upward. It is evident that in the first case

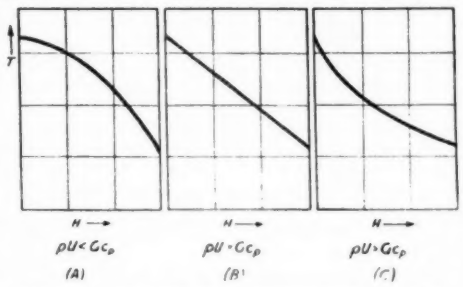

FIG. 1.—TEMPERATURE DISTRIBUTION IN THE BURDEN.

(Fig. 1a) the stock is exposed to a high temperature in a larger volume of the furnace, and hence for a longer time, than in the last (Fig. 1c).

Heat Capacity of Charge

The heat capacity of the stock flow depends to a marked extent on the burdening of the furnace since the heat capacity of the burden is twice that of the coke charged with it; while on a unit volume basis the heat capacity of the burden is three times that of the coke. The control of crucible temperature that is used in practice, by changing the ratio of burden to coke in the furnace charge, probably depends on the effect described above rather than on changes in the combustion temperature, to which the control is usually ascribed. Thus, when the furnace is found to run cold, extra coke is charged which tends to decrease the average heat capacity of the stock flow; hence, the ratio of stock flow to gas flow decreases, and the temperature distribution changes toward that of Fig. 1a. This occurs without any change in the combustion temperature, which is, in fact, very insensitive to changes in either stock flow or gas flow above a certain lower limit; and comes about entirely through changes in the physical—not chemical—character of the stock column.

The blast-furnace operator's demand for an easily combustible coke does not, however, always resolve itself into a request for a coke that is highly reactive, chemically. In many cases where the coke is said to be hard to burn, the statement is made that, when using this coke, the furnace will not "take the blast." This evidently means that the blast pressure required to drive the customary volume of air through the furnace is higher than usual; in other words, that the troublesome coke produces a stock column of high resistance to gas flow.

Resistance to Flow of Gases

Now the resistance of a bed of broken solids to the flow of gases through it depends on the volume of open spaces or "void volume" of the bed, and the specific surface of the bed, that is, the extent of the surface of solid particles in unit volume of the bed over which the gas must travel. Both of these characteristics, in so far as they depend on the properties of the coke, are determined by its size and size distribution. They are, however, greatly influenced by the size and size distribution of the burden as well.

The specific surface, an increase of which causes an increase in the resistance of the bed to flow, depends inversely on the particle size of the material. Roughly speaking, a cubic foot of 1-in. coke will have twice the surface of a cubic foot of 2-in. coke, four times that of 4-in. coke, and so on. Reactions between solids and gases depend to a considerable extent on the magnitude of the specific surface, increasing as it increases. Hence, while a large size is desirable from the point of view of minimum resistance, a small size is desired for good gas contact. In most reactions it is necessary to compromise between these two effects.

Void Volume

For a closely-sized material, packed to its greatest bulk density, the void volume tends to be independent of the size and depends only on the shape of the pieces. For smooth spheres the minimum void volume is about 26 per cent. in the densest packing; but for closely-sized coke, whose surface is rough, the volume of spaces between the pieces may be greater than half the total volume. When a mixture of sizes is shaken down to its minimum volume, the voids are decreased from that found with uniformly-sized material. This fact is used in making high-strength concrete mixes, in which the strength goes up—and the permeability goes down—as the void volume is decreased. Hence, for concrete mixes the volumes of gravel, sand, and cement are carefully adjusted to give minimum voids. On the other hand, for easy gas flow through a bed, the void volume should be as high as possible, so that mixtures of sizes should be avoided. This is the basic reason for requiring coke of uniform size for blast furnaces.

But having produced a porous bed by careful coke sizing, one proceeds, in the blast furnace, to fill up those open spaces with the burden. Of course, the ore and stone is required to be fairly small in size, so that the reducing gases can act on them without having to diffuse a long way through small pores, but it can easily be seen that this is just the procedure that will fill the voids up most effectively. Measurements of the actual void volume in the stack have given values of the order of 9 per cent., which is just what would be expected if the 30 per cent. void volume of a large-sized aggregate were filled with a small-sized aggregate which itself packed with 30 per cent. voids. It is evident that the presence of small coke in the stock actually will take up space that should be reserved for ore and stone.

One additional fact should be mentioned before leaving the subject of void volume. The minimum voids for any bed can only be attained by careful shaking down without too great a movement. In any system, however, in which the bed undergoes constant movement, the bed will not reach its minimum void volume, and the portions of the bed in which the greatest flow of stock occurs will be the least tightly packed and will offer the lowest resistance to gas flow. This has both favourable and unfavourable results; favourable, because the greatest volume of gas is automatically deflected

Blast-Furnace Coke

into the channels through which the stock moves downward most rapidly so that its short exposure time tends to be compensated for by hotter, more active gas; and unfavourable, because this behaviour tends to establish channels and upset the uniform movement that is generally desired.

Thus, it appears that the desired temperatures below the mantle will be attained if the stock is controlled physically. The stock column must be kept open to permit free and uniform gas flow; and the proper ratio of burden to coke must be maintained to give the desired length of the high temperature zone.

Rate of Reduction

The question arises whether the chemical reactivity of the coke may not be of greater importance in the upper part of the stack than it is at the lower levels. In this connection it must be remembered that the chemical reactivity of the coke can affect the rate at which it reduces carbon dioxide to carbon monoxide only within a very small temperature range. Above temperatures of 1,050 to 1,100 deg. C. (1,900 to 2,000 deg. F.)—the rate of reduction is almost independent of the reactivity of the coke, since it becomes, relatively speaking, a fast process and is limited only by the rate at which carbon dioxide can be brought in contact with coke surface by the scrubbing action of the gas. On the other hand, below 850 to 900 deg. C. (1,550 to 1,650 deg. F.), the rate of reduction is negligibly slow for any coke hard enough to be used for blast furnaces, so that any feasible increase in reactivity of the coke still would not appreciably change the carbon dioxide concentration below this temperature.

In the 400-ton furnaces investigated by Kinney the reduction of the ore was almost complete by the time it reached the 850 deg. F. level, so that in these furnaces production of CO_2 from this source occurred well above the level in the stack at which reduction by the coke has practically stopped. Hence, in these furnaces, all the coke had to do was to supply a bosh gas of low CO_2 content to the stack, and almost any coke could do that.

On the other hand, in the 700-ton furnace that Kinney worked on, only a quarter of the reduction of the ore appeared to take place above the 850 deg. F. level, but in this furnace the stock column was badly channelled, so that steps to improve stock and gas distribution were being taken by the operators. Since the stock flow may well have been as irregular as the gas flow, averages over the area of the stock column are not reliable. It should be noted that in the annular space through which most of the gas passed, and hence through which most of the stock may have flowed, the reduction was relatively complete at the 850 deg. F. level, 24 ft. above the tuyeres. Thus, it might be expected that if the furnace were operating smoothly, even with high operating rates, the reduction of the ore may take place above the point at which the coke ceases to act on the gas. It would be desirable, in this connection, to have similar measurements on a smoothly operating, modern 1,000-ton furnace.

It appears that the hypothesis is, at least, tenable, even if not proven, that the chemical reactivity of the coke is without influence in the upper part of the stack, as well as below the mantle. Thus, in this region, the function of the coke is to provide an open, supporting structure in which the ore and stone can lie exposed to the action of the gas.

Coke-to-Iron Ratio

It is surprising how closely the range of coke rates observed in practice is matched by the ratio of coke to iron in a mixture such that the void volume of the coke is just filled up with burden. For example, if a coke bed having 40 per cent. voids were filled with a burden containing 48 per cent. iron and weighing 150 lbs. per cub. ft., the ratio of coke to iron in the mixture would be 2,640 lbs. per ton. If, on the other hand, the void volume were increased to 50 per cent., say, by more careful sizing, the ratio of coke to iron would be decreased to 1,700 lbs. per ton. This coincidence suggests that the principal factor governing the opeartion of the furnace may be this requirement, that the coke provides sufficient free space just to support the burden, and that the departures from smooth operation that are ordinarily observed may be due to small changes in the volume of open space.

If this should be the case, the bulk and apparent specific gravities of the coke would be its most important criteria of operating satisfaction. On this assumption, examine what would happen if the bulk density and apparent specific gravity of a coke were increased by 10 per cent. If no change in charging practice were made, the ratio of coke to burden in the stock would be increased by 10 per cent., and if no change in the rate of blowing were made, it is evident that the rate of flow of stock down the furnace would decrease by 9.9 per cent., since a constant rate of blowing will burn a constant weight—not volume—of coke. Hence, the production rate will decrease, and the coke rate will increase by 9.9 per cent. for the same blast volume and pressure. Referring to the earlier discussion of the heat capacity of the stock flow, the furnace will run hot.

Reducing Coke Sizes

What would happen if, when the observed change occurred, one attempts to compensate for it by cutting down the size limits on the coke to obtain a more open structure and thus get the same bulk density as before, with the increased apparent density? If the void volume before the change had been 50 per cent., this would require an increase of 9 per cent. in the void volume; if the void volume before the change had been only 40 per cent., the increase in void volume would be 13.5 per cent. If no change in filling practice occurred, the same volume of burden as before would now be distributed through a larger volume so the same amount of air could be blown with a lower pressure, but the top temperature would probably go up, and the solution loss increase, resulting in a small increase in coke consumption. If the decreased pressure drop is taken advantage of to increase the blowing rate, an increase of about 5 per cent. in production rate could be attained, with a still greater increase in top losses and coke consumption.

If, on the other hand, the increased void volume had been filled up with burden, resulting in a decrease of coke ratio by 10 per cent., the pressure required to maintain the blast rate would increase, and the furnace would run colder than before the change. Thus, in order to produce the same quality iron, the burden would have to be cut down. It is evident that, following a given change in coke apparent density, there will be only one value of void volume (or bulk density) at which the ratio of coke to burden will be the same as before the change, and for which the same degree of packing of the stock will be obtained. In the example cited, in which the apparent density was increased by 10 per cent., the increase in void volume required to maintain the same coke ratio would be about 2.3 per cent., so that, on the average, a cubic foot of stock would contain 5 per cent. more coke and iron, and for a given rate of production the stock would have a linear flow velocity 5 per cent. less than prior to the change.

Marked Effect of Small Changes in Coke Properties

This discussion shows, among other things, how large an effect certain small changes in coke properties may have. This recalls a suggestion that the best thing a research laboratory could do for the blast furnace was to develop tests of coke quality that could be performed between the time a skip was loaded and when the coke landed on the stock column. The author believed that was the wrong way to go at the problem, even though it is true that before a coke analysis is now available, the coke concerned has already been burned. In the first place, the difficult and time-consuming part of coke testing is not the testing itself, but the sampling. This procedure, in fact, is usually done so that the sample obtained is not actually representative of the lot. There is no way at present in sight by which the sampling could be speeded up. Furthermore, even if such a method were available, the expense involved in sampling and analysing every skip of coke hoisted would probably be out of all proportion to the benefits to be gained.

It appears that it would be much more economical to insure that the coke arriving at the furnace top was so uniform that only samples representing a relatively long period of operation need be taken. There are several reasons for this, but perhaps the most important is that, regardless of the character of the coke supplied, economical operation can be secured if the quality of the raw materials is uniform regardless of their actual quality level.

Improving Uniformity of Coke

Methods for improving the uniformity of the coke are available. Fluctuations in coke quality are due mainly to fluctuations in the analysis of the coal supplied to the ovens, and to a smaller degree to changes in oven practice. It is recognised that coal supplied from any mine has a normal range of variation in analysis. All the analytical properties show such variations, but the ash content is customarily taken as the criterion of variability. Thus, the variation may be represented by the probable error of the ash content of the coal taken in carload lots, and may be as great as 0.5 to 1.0 per cent. of ash. The significance of this is that, if the probable error is 0.5 per cent., then half of the cars will have ash contents lying between 0.5 above and 0.5 per cent. below the average, 82 per cent. will lie between 1.0 per cent. above and 1.0 per cent. below the average, and 96 per cent. will lie between 1.5 per cent. above and 1.5 per cent. below the average.

Such variations as this, transmitted to the blast furnace as coke ash, are probably responsible for fluctuations in the operating behaviour. The variations can, however, be materially diminished by attention to mixing and piling in storage and removal from storage. Suppose that when the coal is stored each carload is spread out over a large area, one on top of the other, so that, when the coal is recovered and charged to the coke-oven weigh lorry, coal is taken from nine different original carload lots. Then the probable error of the ash by lorry-fulls will be only a third of that by car-fulls. If, as in the example above, the standard deviation, by carload lots, was 0.5 per cent., so that 96 per cent. of the cars had ash contents within 1.5 per cent. of the average, the mixed coal in the lorry would have a standard deviation of 0.17 per cent., so that 96 per cent. of the lorry loads would be within 0.5 per cent. of the average. The same principle may also be applied to the coke, and will be especially valuable where coke is supplied from two or more batteries of ovens having different characteristics.

Increased uniformity can be secured by this method in many cases simply by more careful operation of coal-loading equipment, and in other cases by relatively minor additions to loading and storage equipment. The value of such improvements is to be gauged by comparison with the improvement in operating practice to be gained by increased uniformity of product throughout the steel mill, not merely by the cost of the testing and laboratory work whose need has been eliminated

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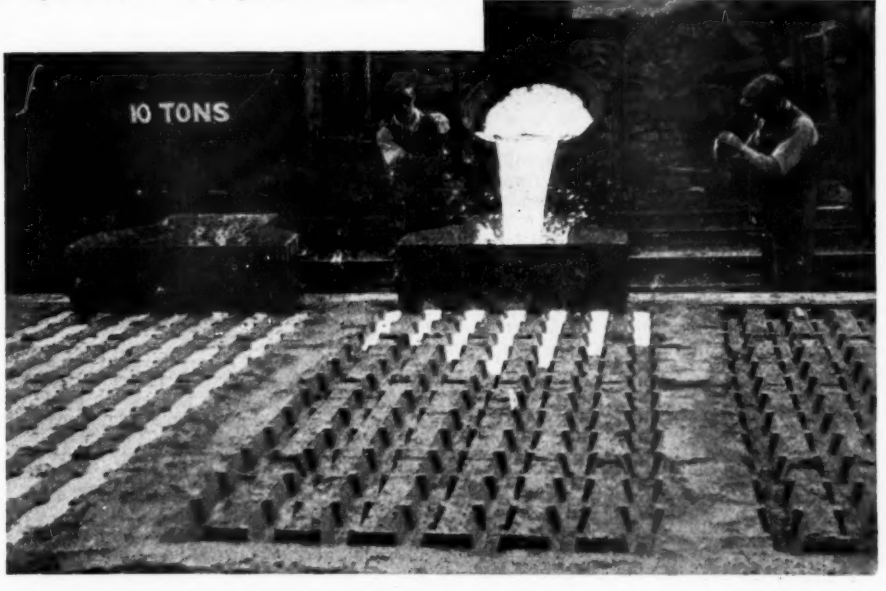

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The Indian Steel Industry

RAPID EXPANSION TO MEET WAR DEMAND

By far the largest contribution by industries in India to the war effort is that being made by the Indian iron and steel industry, states "Commerce." The expansion of ammunition production and the stimulus given to industrial activity by war conditions have created a strong demand for all products of the iron and steel industry. Consequently, the production of pig-iron in 1939-40 exceeded the record of 1937-38 and amounted to 1,838,000 tons; the output of both steel ingots and finished steel continued to move upward. Demands for pig-iron for export, especially from the United Kingdom, which amounted to 125,000 tons in August-September, 1940, have been, if anything, increasing. Since September, 1940, about 50,000 tons have been supplied every month.

It is authoritatively claimed that in all but special steels the industry is now able to meet nearly all the requirements of the country's defence forces with a substantial surplus to the common cause. Not only the routine production of structurals, rails and galvanised sheets for supply to the Army and for the Government's programme of expansion has been undertaken by the industry, but also a large tonnage of special bar for the production of shells. A bullet-proof armour plate made of special alloy steel is being rolled, heat-treated and fabricated into bodies of fighting vehicles. This plate has stood severe firing tests demanded by the British armour plate specification and is considered by the Government to be equal in quality to similar armour plate made in Britain.

Development work on the production of special alloy steel sheets for the manufacture of steel helmets for the Indian fighting forces, and of steels for armour-piercing bullets and shot spring steels for machine-guns, deep drawing steels for rifles and machine-gun magazines, and anti-aircraft cartridge clips and nickel-steel sheets for fabrication into gun platforms and carriages is being carried out. Another line of research successfully pursued is in connection with the welding of chrome-molybdenum steel for the manufacture of aircraft in India. A special type of steel has been manufactured for drawing into telegraph wires. Expansion of the production of electric cables is under consideration. Steel mill rolls, which until recently were exclusively obtained from America and the Continent, have also been made.

A further development in the industry worthy of mention is the manufacture of acid steel from indigenous materials. This steel is essential for gun forgings and gun-carriage axles, the manufacture of locomotive wheels, tyres, axles, etc., and is of considerable importance to the Government's wartime requirements. A firm is erecting a steel-making plant which will increase its capacity by 200,000 tons a year, of which, it is estimated, 70,000 tons will be of acid steel. The manufacture of steel by the electric process has made some progress and manufacturers of hardware and cutlery have received orders from the Government.

One firm is contemplating the erection of a billet mill for rolling billets suitable for several types of forgings, as well as an ingot mould foundry to increase the output of castings. More electric furnaces have been installed and certain firms have worked out a plan for the installation of a hoop and strip mill and a tube mill for the conversion of tube strip into welded tubes. The Tata Iron & Steel Company, whose report was reviewed in our issue of November 27, has installed a new "A" blast furnace, one of the largest and most up to date in the world, with a daily production capacity of 1,700 tons. It is expected that this will raise the company's annual production capacity of pig-iron to 1,250,000 tons.

Grit-Blast Descaling of Steel Tubes

Mill scale can be removed from steel tubes either by pickling or by a sand blast. Pickling has various disadvantages, being tedious, messy and requiring tanks large enough to take the long tubes. One advantage of sandblasting is that it leaves the surface clean and suitably roughened for further treatment, *e.g.*, with paint. Particularly good results can be obtained when using chilled-iron grit, points out R. MATZKE in "Stahl und Eisen," for which however an appropriately-designed plant for efficient descaling of both the inside and outside of tubes of different lengths is needed.

An up-to-date plant described by the author employs centrifugal force for the exterior blast and compressed-air for cleaning the inside of the tubes, the latter being run into the blasting tunnel on a truck. During descaling the tubes are rotated. The pressure used for the internal blast is 50 lbs. per sq. in. gauge. The grit is reclaimed and passed through a reconditioning stage. Arrangements are also incorporated to suppress dust formed by attrition of the scale and any airborne grit particles. Using chilled-iron grit, tubes between 40 and 600 mm. in dia. and up to 15 m. in length can be descaled. Experience with the plant has shown that it is not economical to design a plant to take too wide a range of diameters; separate plants should be installed for narrow diameter ranges, *e.g.*, 100 to 500 mm., 500 to 900 mm., 900 to 1,300 mm., and 1,300 to 1,700 mm. One of the chief advantages of the process is its low power consumption, as compared to a plain compressed-air descaling plant; for instance, an impeller, 550 mm. in dia., with 12 blades and revolving at 3,000 r.p.m., absorbs approximately 8.5 kw.; its performance is the same as two nozzles of 100 mm. dia. with a blast pressure of 50 lbs. per sq. in., which at the compressor would absorb about 54 kw. The grit-blast plant is also smaller than one operating exclusively on compressed air, while the grit used can be recirculated 250 to 300 times before it is reduced to too small a size for further use. Quartz sand can be used only two or three times.

Corrosion and Mechanical Properties

In a Paper in the "Archiv für das Eisenhüttenwesen," W. PATTERSON and E. PIWOWARSKY describe work on the effect of prior and simultaneous corrosion in town's water, dilute sea water and brine solutions on the tensile strength, elongation, reduction in area, bending strength, flexing properties, notched bar values, and the structure of machined and unmachined grey-iron castings with 1.6 to 3.8 per cent. C. The results show that corrosion only slightly affects the physical properties, the effect in general being so small that cast iron appears to be much more reliable in these respects that material in competition with it for structural parts subject to extreme service conditions. Precise quantitative conclusions as regards the effect of corrosion on some of the properties studied could not be drawn owing to the wide scattering of the readings made.

Heat-Resisting Fe-Al Alloys

Investigations of the cast structure, forgeability, impact strength, hardness and scaling in still air at 1,100 deg., of Fe-Al alloys with 5 to 10 per cent. Al were carried out by H. CORNELIUS and W. BUNGARDT, according to their Paper in the "Archiv für das Eisenhüttenwesen," in order to determine whether the addition of C, Mn, Ni, Co, Cu, Ag, Si, Cr, W, Mo, V, Ti, Ni + Ta and B would improve the forgeability and reduce the brittleness, without adversely affecting the thermal resistance. The authors found that the brittleness of these alloys could be considerably reduced by the addition of small quantities of Ti, Ta and Ni, without affecting any of the other properties. Even with these additions these alloys are still too brittle for use as non-scaling forgeable materials. Although boron also reduces the brittleness, the resistance to scaling is seriously increased.

Rapid Blast-Furnace Re-Lining

When No. 2 blast furnace at Iscor Works, Pretoria, was re-lined toward the end of last year and iron produced 72 days after the last cast of the previous campaign, it was considered that the Empire record of 78 days, held by the Broken Hill Company of Australia for a similar undertaking, had been broken. Shortly after this, however, it was learned that a new United States record of 60 days, for re-lining a 600-ton furnace, had been achieved, reckoning from blast off to blast on again. The furnace belonged to Wisconsin Steel Company, Chicago.

This provided an incentive for Iscor to prepare a special effort on their No. 1 furnace, which was due to come off for repairs and re-lining at the end of May. A rough time-table for the various parts of the complete job was drawn up and consisted of the following items: (1) Cooling down the furnace with water sprays; (2) raking out remaining materials; (3) removing top gear and old brickwork; (4) blasting out the "bear" (which is the metal accumulated below the taphole level and which solidifies during the cooling down); (5) removing and repairing damaged hearth jackets and one column; (6) re-bricking the furnace; (7) replacing top, coupling up water cooling pipes, tapping troughs and mudgun, while drying out the furnace; (8) overhauling gas-cleaning plant and charging gear; and (9) installing new coke screening equipment.

The time-table drawn up was: Dismantling and repairs, 24 days; brickwork, 27 days; drying, filling and drafting, 9 days; a total of 60 days. Actually the work kept ahead of schedule almost from the start. The furnace was stopped at 9 p.m. on May 31, and although the hearth jacket repairs were heavier than anticipated, the bricklayers were able to begin work on the morning of June 23—about two days ahead of schedule. The brickwork progressed very well and was finished on June 15, or seven days before the anticipated time, and occupying five days less than was anticipated.

As mechanical and electrical work had to go on at the same time as the bricklaying, careful co-ordination was obviously required to prevent the one job holding up another. As the furnace contains about 1,200 tons of refractories, an average of over fifty tons were laid per day.

The new breeze screening equipment gave a little trouble at first, but despite this, drying, filling and drafting took only ten days, so that the blast was finally put on at 8.15 a.m. on July 25—just over fifty-four days from the last cast of the previous run. Metal was tapped at 2.30 a.m. on the following day—less than 55½ days from stopping.

This feat is claimed by Iscor to be a world record, and is certainly a fine achievement, although, of course, strict comparisons for obvious reasons are extremely difficult between one furnace and another.

Soviet Manganese

Before the first world war Russia's annual output of manganese was in the vicinity of 1,000,000 tons a year. Production dropped to almost nothing during the post-war period. By 1929, however, it had been developed to 1,400,000 tons, and it is considered that this output has since been doubled, the latest available figure being an estimated production of 2,700,000 metric tons during 1937. There are two principal manganese-producing districts—Tchiature in Georgia, east of the Black Sea, and Nikopol in Southern Ukraine. The output of the former used to furnish the bulk of the exports, while that of the latter was used mainly for domestic consumption. In 1932, operations were begun in Siberia to supply the Stalinsk steel plant at Kutznetsk. Whereas exports used to amount to 75 per cent. of the total output, domestic consumption has been increasing steadily ever since the expansion of Soviet industry began.

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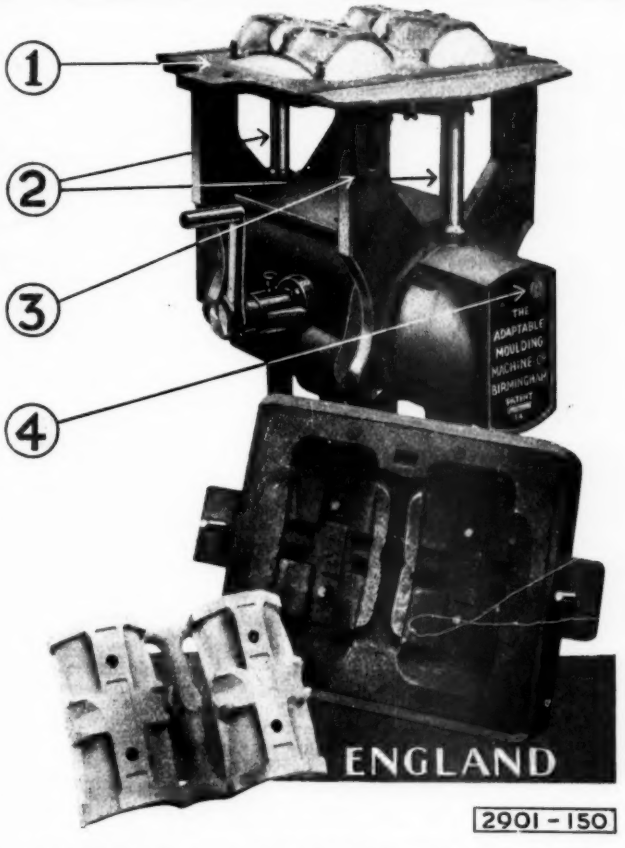

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Supply of Electrical Equipment

SCHEME TO FACILITATE PRODUCTION

By arrangement with the Iron and Steel Control, the Directorate of Industrial Electrical Equipment, Ministry of Supply, will in future issue bulk authorisations for iron and steel to manufacturers for any industrial electrical equipment coming within the following categories:—

(*a*) *Rotating Machinery*.—A.C. and D.C. motors up to and including 250 h.p.; D.C. generators up to and including 250 k.w.; alternators up to and including 250 k.v.a.; converters and frequency changers up to and including 40 k.w.; pulleys, couplings, clutches and gears integral with the above machines.

(*b*) *Switchgear and Control Gear for Industrial Purposes*.—Starters, regulators and associated equipment for use with the above rotating machinery for any voltage; switches, fuses, switchboards, distribution boards, circuit breakers and isolators, all ratings up to and including 650 volts.

As the main purpose of this arrangement is to facilitate production and supply for essential purposes, the manufacturer is free to supply any "specified equipment" when he has received written evidence that the demand is covered by one of the "approved" categories. For part of the range of "specified equipment" certain categories will still be subject to the Board of Trade Machinery, Plant and Appliances (Control) Orders, and the appended notes indicate when manufacturers are free to supply without licence or other formality and when a Board of Trade licence is necessary:—

The range of "specified equipment" comprises the following: (A) Motors up to 50 h.p.; generators up to 25 k.w.; alternators up to 25 k.v.a.; converters and frequency changers up to 40 k.v.a.; control switchgear for the above up to 500 amps. (B) All items specified under (A) but "over" the capacities indicated.

When ordered directly by, or on behalf of any Government Department, or by any sub-contractor as part of a contract for which the Government is the ultimate paymaster, (A) and (B) may be supplied without licence. When ordered by a mining undertaking on the authority of the Mines Department of the Board of Trade, (A) and (B) may be supplied without licence; and also when ordered by a public-utility undertaking on the authority of a Government Department. When, although not covered by the above, the purchaser has a written authorisation by a Government Department for the order, (A) may be supplied without licence, but (B) requires a Board of Trade licence. For the following both (A) and (B) may be supplied without licence: When required for actual use with a machine tool; when ordered by any manufacturer for actual use with machinery or plant made or under construction by him for resale, or for which he has a licence to import. (NOTE.—A manufacturer of "controlled" machinery or plant must perform a process of manufacture before sale.) When required for actual use with machinery or plant for which a licence has been granted under the Board of Trade's Machinery, Plant and Appliances (Control) Orders and for which no driving means is already available; when required for export and the Board of Trade, either through an Export Group or otherwise, have approved the manufacture for export (NOTE.—It is still necessary to comply with any Board of Trade regulations dealing with export licensing for particular equipment or destinations); when required for actual use to meet statutory safety regulations or for purposes of repair to maintain industrial electrical equipment in its existing use. When required for use in any works listed in the Essential Work (General Provisions) Order, 1941, and a director or secretary of the purchasing company certifies that the equipment is required for actual use in connection with essential war production, a B.O.T. licence is required for (B) in this case; as regards (A) there may be supply without licence, except when the driven machinery is "controlled" under the Board of Trade Machinery, Plant and Appliances (Control) Orders.

The scheme came into force on January 1. Manufacturers requiring further information should apply to the Controller General of Machine Tools, Ministry of Supply (Code V.A.), Machine Tool Control (D.I.E.E.), 35, Old Queen Street, London, S.W.1.

Non-Ferrous Metals

The Ministry of Supply has made two Orders relating to non-ferrous metals, one fixing maximum prices for cadmium and one controlling nickel purchases.

Cadmium Prices.—The Control of Non-Ferrous Metals (No. 6) (Cadmium) Order, 1941, which came into force on January 1, provides that no person (other than a consumer of 10 lbs. or less per month) shall acquire cadmium-bearing ores, concentrates or residues, or cadmium in the form of ingots, sticks or rods, or scrap material containing more than 50 per cent. of cadmium, excepting under the authority of a licence. Scrap which will not be treated beyond cleaning, crushing or sorting is exempted from this provision. Cadmium anodes of ball type and imported anodes of plate type are also made subject to licence on sale or disposal. The Order fixes a maximum price of 5s. 4d. a lb. for cadmium ingots, sticks and rods, delivered to buyers' premises in lots of 1 cwt. or more. For smaller quantities a maximum of 5s. 6d. per lb. has been fixed.

Nickel Control.—The Control of Non-Ferrous Metals (No. 7) (Nickel) Order, 1941, which came into force on January 1, provides that no person (other than a consumer of not more than 1 cwt. per month) shall acquire unwrought nickel, alloys containing not less than 90 per cent. of nickel, and any scrap material (other than iron and steel scrap) containing more than 5 per cent. of nickel, excepting under the authority of a licence issued by the Minister. Scrap which will not be treated beyond cleaning, crushing or sorting is exempted from this provision.

Copies of these Orders may be purchased from H.M. Stationery Office, York House, Kingsway, London, W.C.2, or through any bookseller (price 1d.). All inquiries should be addressed to the Non-Ferrous Metals Control, Grand Hotel, Rugby.

Steel Workers' Clothing

Following discussions between the Board of Trade, the British Employers' Confederation and the T.U.C. regarding the procedure to be adopted for the distribution of supplementary clothing coupons to workers, the Board has now adjusted arrangements with the Ministry of Labour and National Service under which employers of the workers concerned will be able to obtain the necessary coupons through their local Labour Exchanges. A special Schedule (E.D. 272) has been prepared for completion by employers for the purpose, and copies of the Schedule, together with a leaflet detailing the procedure, are now available at all local offices of the Ministry of Labour. The procedure laid down in the leaflet applies at present only to the supplementary coupons in respect of iron and steel workers, but it is anticipated that the same procedure will be followed in respect of most other awards which may be made from time to time by the Board. The procedure will, however, not apply to the coal industry, in respect of which other arrangements have already been made. Employers of iron and steel workers entitled to supplementary coupons should apply to their local Exchanges for copies of the Schedule and explanatory leaflet as soon as possible after January 1, and not later than January 14.

Sub-Authorisations for Iron and Steel

Under the present regulations, the holder of an authorisation to acquire iron and steel who wishes to delegate a part of this authorisation to a sub-contractor must issue a sub-authorisation on Form M. In order to save clerical labour and forms, it has been decided to give holders of authorisations the option of issuing sub-authorisations either on Form M, as at present, or by providing the following particulars on their orders:—

Department Symbol: .....
Dept. Authorisation No.: .....
Delivery Period No.: .....
Tonnage for this order:—
Non-Alloy Steel: .....
Alloy Steel: .....
Iron Castings: .....

Authorised on Form M under Control of Iron and Steel (No. 15) Order, 1941.

It is understood that there is no objection to holders of authorisations stamping these particulars on orders.

New Year Honours

Among the names appearing in the New Year Honours List are the following:—

BRIG.-GEN. THE RT. HON. SIR AUCKLAND CAMPBELL GEDDES, who becomes a baron in recognition of his public services, is chairman of the Rio Tinto Company, Limited, and the Rhokana Corporation, Limited, and a director of other mining companies. He was President of the Board of Trade from 1919-20, when he became British Ambassador to the United States, a position he occupied until 1924.

COMMANDER SIR CHARLES WORTHINGTON CRAVEN, Controller-General, Ministry of Aircraft Production, is one of the two new baronets. Sir Charles is chairman and managing director of Vickers-Armstrongs, Limited, and the English Steel Corporation, Limited, chairman of Firth-Vickers Stainless Steels, Limited, Michell Bearings, Limited, and Palmers Hebburn Company, Limited, and is on the board of Vickers, Limited, Guest Keen Baldwins Iron & Steel Company, Limited, National Shipbuilders' Security, Limited, and other companies. He is chairman of the Industrial Welfare Society.

MR. RICHARD W. ALLEN, chairman of W. H. Allen, Sons & Company, Limited, Bedford, engineers and ironfounders, is among the list of knights bachelor. He is a Past-President and an hon. life member of the Institution of Mechanical Engineers and a member of the Iron and Steel Institute.

MR. ROBERT STUART HILTON, deputy-chairman of the United Steel Companies, Limited, and President of the British Iron and Steel Federation, is one of the new knights. He is chairman of the Appleby-Frodingham Steel Company, Limited, Samuel Fox & Company, Limited, Workington Iron & Steel Company, Limited, United Coke & Chemicals, Limited, Risehow Colliery, Coking & By-Product Company, Limited, and the Moresby Coal Company, Limited. He is also on the board of John Summers & Sons, Limited, Sheffield Coal Company, Limited, Templeborough Rolling Mills, Limited, and other companies.

MR. GUY H. LOCOCK, director of the Federation of British Industries, has received a knighthood.

MR. GEORGE CLEMENS USHER, Director-General of Tank Supply, Ministry of Supply, who receives a knighthood, is chairman and managing director of International Combustion, Limited, and chairman and joint managing director of Aberdare Cables, Limited.

SIR FRANK EDWARD SMITH, Controller of Telecommunications Equipment, has been awarded the G.C.B. for services to the Ministry of Aircraft Production and the Ministry of Supply. He was secretary of the Department of Scientific and Industrial Research from 1929-39, hon. secretary of the British Association for Advancement of Science, 1922-29, secretary of the Royal Society, 1929-38, superintendent of the Electrical Department of the National Physical Laboratory, 1901-20, and director of Scientific Research, Admiralty, 1920-29. Sir Frank has been honoured by many scientific bodies.

MR. SAMUEL RICHARD BEALE, who receives the K.B.E., is a member of the Industrial and Export Council of the Board of Trade. He is chairman and managing director of Guest, Keen & Nettlefolds, Limited, chairman of John Lysaght, Limited, Haslam Foundry & Engineering Company, Limited, Universal Grinding Wheel Company, Limited, and Worthington-Simpson, Limited, and a member of the board of Glenfield & Kennedy, Limited, Joseph Sankey & Sons, Limited, Mavor & Coulson, Limited, Orconera Iron Ore Company, Limited, and other companies. He was president of the Association of British Chambers of Commerce in 1934-35 and 1936.

MR. R. H. DOBSON, managing director of A. V. Roe & Company, Limited, has been awarded the C.B.E. for services to aircraft production.

MR. S. P. SMITH, Professor of Electrical Engineering at the Royal Technical College, Glasgow, has received the C.B.E.

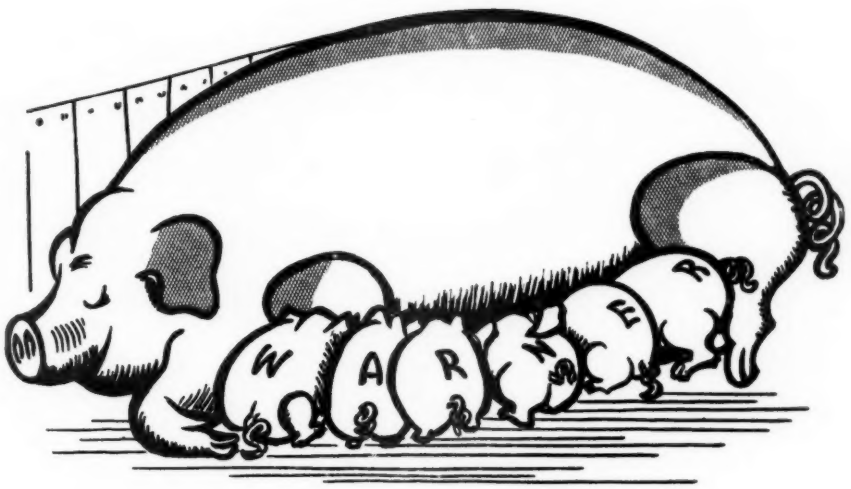
MR. A. WILSON, who receives the C.B.E., is a director of Imperial Chemical Industries (Explosives), Limited, and the award is made for services to the Ministry of Supply.

MR. A. E. REDDELL, who has been awarded the O.B.E., is a director of Vickers-Armstrongs, Limited, and general manager of the Whitehead Torpedo Company, Limited.

MR. PERCY H. MILLS, Controller General of Machine Tools in the Ministry of Supply, who has been made a Knight Bachelor, is managing director of W. & T. Avery, Limited, Soho Foundry, Birmingham.

W

MIGHTIER YET . . .



Present day conditions call for an even larger range of Warner Pigs—in fact we wish we could litter our stock ground with them.

At any rate we are producing many analyses which, though they may not be so familiar to the Foundry Trade as our ordinary grades, are helping numerous firms to solve their war-time problems.

If we can help you, we help Britain to become "Mightier Yet" —that is our conception of war-time service.

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WARNER AND CO. LTD., CARGO FLEET, MIDDLESBROUGH

W

The Week's News in Brief

Trade Talk

AT THE SUGGESTION of the Board of Education, Middlesbrough Education Committee is inaugurating a scheme for intensive training courses in engineering at the Constantine Technical College.

WILLIAM ASQUITH, LIMITED, Halifax, held a formal meeting on Tuesday, December 30. As the accounts in respect of the year ended August 14 last are not yet available, the meeting was adjourned until a later date.

THE NATIONAL ARBITRATION TRIBUNAL has issued an award dismissing a claim for an increase of wages to boys and youths other than apprentices employed by members of the Engineering and Allied Employers' National Federation and its constituent bodies. The claim was made by the Transport and General Workers' Union and the National Union of General and Municipal Workers, and the Tribunal found that the claim had not been established.

DURING A DISCUSSION at a meeting of the Tees-side Chamber of Commerce at Middlesbrough, a speaker suggested that the time had arrived when the Government should start a campaign to remove the psychological objection by workers to the paying of income tax. Many workpeople thought they should not pay income tax. Another member asserted that one of his own employees had refused to accept an increase in wages because, he said, it would only go in income tax. The chairman said he knew cases where boilermakers had asked to work overtime because they were feeling the effects of paying income tax.

ON AUGUST 2 the American Car & Foundry Company delivered its 1,000th combat tank to the U.S. Army, and on October 21 it delivered its 2,000th. In less than three months it equals its production for the preceding twelve months—a fourfold speed-up. The American Car & Foundry Company was the first civilian builder of modern tanks in the United States, and the first to build tanks in mass production. Each tank weighs about 12 tons and requires nearly 4 tons of armour plate, and also contains 2,865 different kinds of parts and 14,318 individual pieces (exclusive of engines and accessory equipment). The works can now produce one complete tank every 45 min.

A NEW QUARTERLY PERIOD of insurance of business equipment under Part II of the War Damage Act began on January 1, and runs until March 31. The premium for this period is 7s. 6d. per £100. Insurance is compulsory where the value of the business equipment held exceeds £1,000. Below this limit insurance is voluntary. All those who are compulsorily insurable, or, if voluntarily insurable, wish to be covered against war damage to their equipment, and who have not already taken out a policy for the six months from October 1, 1941, to March 31, 1942, should apply to their Fire Insurance Company or Lloyd's for insurance for the period of three months from January 1.

NEW RECORDS are being set up by the railways for the rapid handling of war freights. Among the methods which are being tried to move the greatest tonnages at the maximum speeds are the system of nominated loading of trucks; senders now know that goods for particular destinations are forwarded only on certain days of each week. This results in considerable quantities of goods being collected for a destination, and so enables them to be loaded into wagons, which make through journeys without sorting *en route*. Complete trainloads of coal known as "block trains" are being run from the collieries to the consuming centres. These "block trains" go from the pits to their destinations like passenger trains. The collieries are assisting by labelling coal wagons in proper order for the train hauling them to drop the wagons off at various stations *en route*.

IN THE HOUSE OF COMMONS recently, Major Lyons asked the President of the Board of Trade whether he could give any estimate of the compensation paid by nucleus firms to those persons whose businesses had been concentrated therein. Capt. Waterhouse, who replied, said that the amount of compensation paid to firms whose factories had been closed under the concentration policy was in general a matter for private negotiation between those firms and the nucleus firms with whom they were associated. In the majority of cases, the nucleus firm manufactured at cost for the firm with the closed factory and the latter continued to sell the goods so produced on its behalf. In these cases no question of compensation, as the term was generally understood, arose. In a few industries, however, a central compensation fund had been set up. In these cases the Board had examined the compensation schemes so as to ensure that the payments would be sufficient to provide for the adequate care and maintenance of the premises closed down, and that they would be applied in the first instance for those purposes. Neither in the usual case in which the compensation was a matter of private negotiation between two firms, nor in the exceptional case in which there was a central compensation fund, did the question of whether at the time of the concentration the closed firm was making a profit or not arise.

Personal

MR. J. L. PARKER has been elected a director of Short Bros. (Rochester and Bedford), Limited.

MR. LOUIS VANDALLE DUNLOP, general manager of Harland & Wolff's shipyard, Glasgow, has been appointed a Justice of the Peace.

MR. J. W. GARDOM, foundry consultant, has changed his address from The Vicarage, Wessington, to Cromer House, Ripley, Derbyshire.

FLYING-OFFICER G. R. SCORER, B.Sc., recently awarded the D.F.C., is on the technical staff of Meldrums, Limited, engineers, Timperley, Cheshire.

MR. G. HENDERSON, who has been appointed Labour Supply Officer on the Edinburgh District Man-Power Board, took up an appointment with the Ministry of Labour in June, 1940. Previously he was chief technical manager and engineer manager with Bruce Peebles & Company, Limited, Edinburgh. He is Lecturer on Engineering for the Edinburgh Education Authority and at Heriot-Watt College.

THE RIGHT HON. EARL PEEL and MR. LORIS EMERSON MATHER have been elected directors of the Lancashire Steel Corporation, Limited. Mr. Robert Crichton, now a whole-time director, has been elected to the position of a vice-chairman. A similar office is held by the Earl of Crawford. Lieutenant-Commander Geoffrey K. Rylands, the head of the works administration of Rylands Bros., Limited, Warrington, has also been elected to the board of the Lancashire Steel Corporation.

MR. WALTER T. SMITH, of Thomas Smith & Sons (Rodley), Limited, the Leeds crane and excavator manufacturers, retired at the end of last month. He is the second son of the founder, and has been associated with the company for nearly 50 years and joint managing director with his elder brother, Mr. Frederick H. Smith, for 23 years. Mr. Smith has received a presentation from the directors and staff to mark the occasion of his retirement. New directors of the company are Mr. W. H. Sharp and Mr. Thomas N. Smith, grandson of the founder.

Waste Paper Contest

A nation-wide campaign for the salvage and collection of waste paper was begun on New Year's Day, in the form of a contest among the 20 areas into which the country has been divided. The contest has been arranged by the Waste Paper Recovery Association, and a group of public-spirited citizens has provided £20,000 for prizes. There will be £1,000 to be divided among the winning local authorities in each area, a first prize of £500, a second of £250, a third of £100, and three consolation prizes of £50. The winning authorities will be those which collect most paper per head of the population, and can be city, town, urban or rural councils. It is a condition that half of any prize won shall be given by the local authority to one or more of four national charities—the Red Cross, Mrs. Churchill's Red Cross Aid to Russia Fund, the R.A.F. Benevolent Fund, and the Soldiers', Sailors', and Airmen's Families' Association—and the remaining half to local charities. The contest will continue until January 31. Help your local authority to qualify for one of the prizes.

Obituary

MR. JOHN SHAW, late of Benjamin Shaw & Sons, metal merchants, Cradley Heath, died recently at Stourbridge, aged 72.

MR. R. M. PORTER, who carried on business as an ironfounder at Denton Holme, has died at Wetheral, Cumberland. He was 81 years of age.

MR. SEBASTIAN M. G. URE, Assistant Professor of Chemical Engineering at the Imperial College of Science and Technology, died on Christmas Day.

MR. HAROLD BUTLER, managing director of the Butler Machine Tool Company, Limited, Halifax, has died, aged 66. He was the elder son of the late Mr. James Butler, founder of the firm. He was a past-president of the Machine Tool Trades Association, and in 1930 was president of the Halifax Chamber of Commerce.

THE DEATH occurred of Mr. David Hogg, manager of the Middlesbrough office of William Jacks & Company, Limited, after a brief illness, on December 28. He joined the staff of the Middlesbrough office in 1887 and later on was manager of the Sheffield branch. He then returned to Middlesbrough, where his attractive personality made a large circle of friends. During recent years poor health made a lessening of his activities imperative, but he will be keenly missed by his many business associates in the North.

Reports and Dividends

(Figures in brackets refer to the previous financial year.)

Bertrams—Net profit to September 30 last, £7,192; dividend of 10%.

Whessoe Foundry & Engineering Company—Interim dividend of 10%.

Wolverhampton Die-Casting Company—Final dividend of 7½%, making 12½% (nil).

Steel Barrel, Scammells & Associated Engineers—Interim dividend of 6% on the ordinary shares (same).

William Briggs & Sons—Profit to September 30, £94,809 (£64,740); ordinary dividend of 20% (12½%).

Beyer Peacock—Full year's dividend arrears to June 31, 1934, on the 5½% cumulative preference shares.

Wellworthy Piston Rings—Trading profit, after charging depreciation and taxation, £22,359 (£43,859); final dividend on the ordinary shares of 10%, making 15%.

Tomlinsons (Rochdale)—Net profit for the year to June 30, £1,274; forward, £16,176 (£16,706 brought in); dividends on the preference share capital, discharging arrears to June 30, 1938, have been paid.

Jonas Woodhead & Sons—Profit for the year to August 31, £87,849 (£60,120); preference dividend, £3,220; to reserve for taxation and contingencies, £65,000; staff pensions, £5,000; dividend of 10% (same) on the ordinary shares, £10,007; forward, £14,808 (£10,187).

Joshua Bigwood & Son—Trading profit to September 30, £42,782 (£38,079); depreciation, £4,527 (£5,916); war damage contribution, £1,426 (nil); taxation, £27,000 (£17,409); dividend on 6% preference shares, £3,483; ordinary dividend of 10% (same); forward, £2,043 (£2,047).

Cannon Iron Foundries—Net profit for the year ended September 30, after charging depreciation and A.R.P. expenditure, £44,288 (£2,831); taxation, £25,292; war damage contributions, £3,031; dividend on preference shares for 21 months to September 30, 1941, £9,625; forward, £10,257 (£3,919).

Henry Meadows—Trading profit to August 31, £312,661 (£224,382); tax, £191,000 (£124,197); depreciation, £90,698 (£44,849); net profit, £29,363 (£53,736); War Damage insurance, £4,000 (nil); interim dividend of 7½% (same), £7,500 (£9,375); final dividend of 17½% (same), £17,500 (£20,125); forward, £12,135 (£11,772).

South Durham Steel & Iron—Owing to outstanding questions which required to be settled with Government department, it was impossible to prepare and complete the accounts for presentation to the annual meeting on December 17, when, therefore, only formal business was transacted. The directors proposed an interim dividend on the ordinary shares of 6%, as they were satisfied that the profits of the company for the past year permit of the dividend being paid, but they reserved the right when the final accounts are made out to determine whether it shall be treated as a final dividend for the year ended September 30, 1941.

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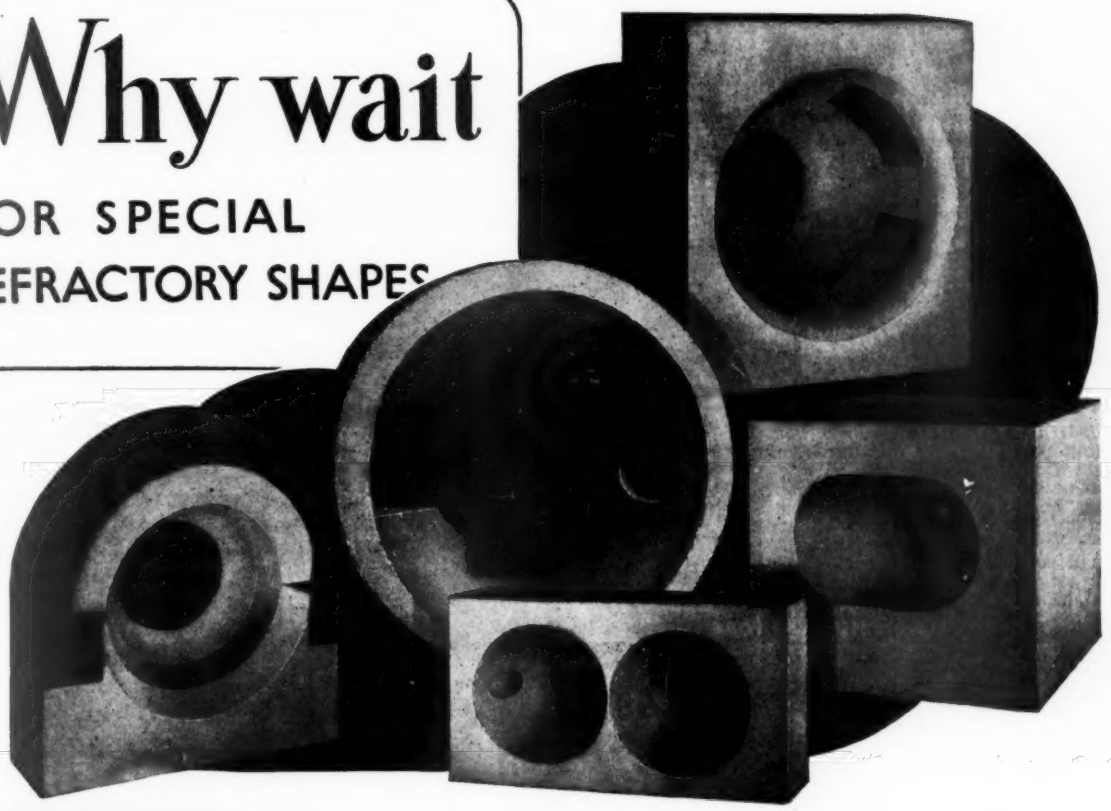

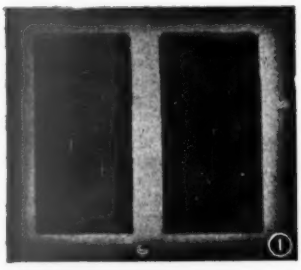

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NO SHRINKAGE Illustration (1) shows two 9 x 4½ x 3 in. blocks cast in moulds and dried at atmospheric temperature. One was fired to 1500° C for four hours. Both specimens are exactly the same size.

STRENGTH. Illustration (2) shows two test pieces cast in moulds, allowed to dry at atmospheric temperature and one heated to 1,000° C. Tensile strength results—*Unfired*, 550 lbs. per sq. in. *Fired*, 1312 lbs. per sq. in.

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BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete. SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.* CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline. Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: Tank Blocks, Bricks and Cements. SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Consumers of foundry iron continue to take up a big aggregate tonnage. It is among the heavy engineering works that orders are placed most freely, many of these establishments being entirely given over to contracts for Government departments. Business in the light-castings section remains dull and little improvement is envisaged for a long time to come. A few of the makers of light castings who have been able to adapt their plant to cope with the needs of the Government are in possession of satisfactory order-books, but others are handicapped severely by the restrictions on ordinary domestic business and the drying up of the export market. In the steel industry very active conditions are reported in nearly all departments, with particular attention being paid to the production of special steels required for the manufacture of munitions, armaments, etc.

Pig-Iron

MIDDLESBROUGH—With the local steelworks operating at capacity, the entire output of basic iron in this district is readily absorbed. Refined iron is also being utilised extensively, while as much hematite as can be procured is going into immediate consumption. The Control is jealously guarding its stocks of hematite, which are now substantial, and there is unlikely to be any relaxation of the conditions governing distribution. In certain cases, of course, hematite is essential, and when this is so, supplies are sent forward to cover all requirements. Common foundry iron is arriving from the producing centres in the Midlands very satisfactorily, and consumers are ordering their needs over the first quarter of the year. Consumption of these grades is somewhat curtailed, as light-castings makers are unable to operate fully, but this is offset to some extent by the use of high-phosphorus iron by heavy engineers because of the shortage of hematite.

LANCASHIRE—Derbyshire and Staffordshire makers of foundry iron report a moderate demand from the Lancashire area, and are promptly supplying users with all they ask for. There is no improvement in the position of light-castings producers, who are experiencing increasing difficulties in securing new business, owing to there being a comparatively small demand for their products from Government buyers. Many jobbing foundries, too, are not well situated, although those connected with the machine-tool trade are enjoying an active trade. Speciality engineers and makers of heavy castings are as busy as they can be on important orders associated directly with the war effort, and should there be any change in their position, it will inevitably be towards further expansion of output. Special refined iron is well taken up, being used frequently to eke out supplies of hematite, fresh deliveries of which are still denied to consumers unless the nature of their work dictates the use of this type of iron.

MIDLANDS—Castings for the munitions programme and other Government work are in great demand, and producers are fully booked up ahead. There is little opportunity for ordinary domestic buyers of heavy castings to obtain their requirements, as official requisitions tend to expand constantly. Makers' iron needs are being met, but this has only been brought about by changes in their mixtures. Hematite, for example, is not to be had even in small parcels, except for consumers who require supplies when they cannot secure satisfactory results by the utilisation of other types of iron. Medium- and low-phosphorus irons, which were very difficult to acquire some months ago, are now rather more freely available, although the supply position is not yet as easy as it might be. Refined iron and steel scrap are being incorporated in mixtures on an extensive scale, thus relieving the pressure on other grades. High-phosphorus iron is in ample supply for all requirements, this quality being produced from ores located in the United Kingdom. Business among makers of light castings remains very dull, with little prospect of improvement; production of domestic castings has been substantially curbed, while the export trade is but a shadow of its former self.

SCOTLAND—Deliveries of pig-iron are still disappointing in certain directions; the quantity of low-phosphorus iron distributed between consumers in this district has not come up to expectations, but hopes are entertained that the year will not be very old before the position eases. Under official direction pig-iron makers are distributing available supplies fairly among users, and operations are not held up because of the slowness of despatch. Heavy engineers are so busy that their New Year holiday was of the briefest duration, but the light-castings industry in the Falkirk area was able to enjoy a longer respite, as business in this section continues to be quite insufficient to enable works to operate very extensively. Iron for makers of light castings is coming through satisfactorily from the Midlands of England, and many consumers have reserves on hand.

Coke

Many foundry-coke users are now benefiting from their prudent policy of stocking supplies while they were readily forthcoming, as deliveries from the ovens continue to be behind schedule, although it is expected that the position will improve within a short time. The price of Durham best coke remains at 62s. 9d. per ton delivered Birmingham and Black Country stations, and all sales are negotiated subject to a rise-and-fall clause, as producers' quotations are outside their jurisdiction, being dictated by the Control authorities.

Steel

The position of the British steel industry has changed in recent months in several respects, and it is fully appreciated by all concerned in production circles that the year 1942 will tax the industry's resources to the limit of its capacity. Imports of American metal have been cut down to the minimum, not because of the entry into the war of the United States, but in furtherance of the policy evolved for reducing to bare necessities all imports into Great Britain, a policy with obvious advantages to the nation. The needs of the Government's munitions programme have also changed, present requirements centring around special alloy steels as against the ordinary carbon qualities formerly in greatest demand. Production of alloy steels, already increased very considerably, will be still further enlarged in the near future.

Scrap

The rapid stepping-up of steel output is reflected to a considerable degree in the demand for steel scrap, and basic furnaces absorbing very large quantities. On the whole, demand is being met quite well, but many complaints are received from time to time of the inferior quality of the scrap metal delivered to steelworks. It is more and more noticeable that the labour available for the collection, grading and preparation of scrap to furnace sizes is quite insufficient numerically to cope with the situation, and early attention to this matter is imperative.

Metals

COPPER—There is little fresh to report with regard to copper in this country; essential requirements are being met satisfactorily, large tonnages being used up by factories engaged on war work. In the United States, the authorities are concentrating on the restriction of the use of the metal for other than vital needs and appreciable limitations were imposed upon civilian consumption as from the beginning of the year. It is of interest to note that the possibility of silver being used as a substitute for copper is being investigated in America. Mr. R. E. McConnell, chairman of the Engineers' Defence Board, has stated that the Government would have to dig into its hoard of silver to find a substitute for copper as an electrical conductor. It is reported from Canada that contracts for the sale to the United Kingdom of a very large percentage of Canada's copper, lead and zinc outputs have again been renewed. Involved in the contracts are 210,000 short tons of electrolytic copper, the total surplus of zinc after home needs have been met, and an undisclosed tonnage of lead.

TIN—There is still no news regarding the price at which the Ministry of Supply will requisition tin supplies. The Government's methods of imposing control on the metal have not been at all well received by dealers, who feel that it is inequitable for their holdings in the Straits Settlements to be left on their hands. They assert that tin control should be extended to include the whole British Commonwealth. The position of the tin-mining and smelting industry in the East is extremely perilous, and it seems inevitable that Japanese air attacks will be concentrated on the tin-producing areas of the Dutch East Indies before long. So far, however, the tin areas are believed to have escaped much of the attention of the raiders. Now that the United States is an active participant in the war, she has naturally to look after her own interests more judiciously, and exports of American tinplates to Empire destinations will henceforth be appreciably lower. This has resulted in the allocation to Welsh tinplate mills of a larger tonnage of steel for the first quarter of the year.

SPELTER—For a long time past supplies of spelter available for distribution in the United Kingdom have been no more than sufficient to satisfy urgent requirements, and it is obvious that non-essential consumers will not be more favourably treated while the necessity for meeting the demands of war contracts exists. The zinc position on the other side of the Atlantic remains tight, but some relief has been afforded by the cutting down of deliveries to civilian users. An agreement between the Defence Plant Corporation and the American Zinc Company, of Illinois, provides for a further expansion of U.S. productive capacity. The American Zinc Company will erect a plant with an annual capacity of about 17,000 tons of electrolytic zinc and 7,200 tons of retort metal. According to the American Bureau of Metal Statistics, the United States imported 34,073 short tons of zinc in ore in September last, making for the nine months 182,107 tons, compared with 128,582 tons in January-September, 1940. Imports of spelter were 3,415 tons in September, making for the nine months 25,209 tons (mainly from Mexico), against 9,718 tons a year ago. Exports were 7,656 tons in September, making for the nine months 57,909 tons, compared with 59,299 tons in January-September, 1940.

LEAD—Cable and battery makers continue to be the chief consumers of lead, being actively employed on Government orders. Supplies at present are quite sufficient to meet all requirements, but the difficulty of maintaining Burmese exports under existing conditions must give rise to a certain amount of disquiet, while the future of shipments of lead from Australia also has to be viewed with some reserve.

Selling Prices for Non-Ferrous Scrap

The maximum prices for non-ferrous metal scrap subject to control remain at the established levels, but in connection with steps taken recently to secure a better utilisation of scrap metals the Non-ferrous Metals Control are now quoting weekly prices for process and manufacturing scrap resulting from strip, sheet, plate and tubes which are intended to represent the current market values. The following prices are for the week ended January 3, and are issued from the Office of the Joint Controllers of Non-ferrous Metals. They are all net, per ton, ex-sellers works, suitably packed:—

Brass.—S.A.A. webbing, £48 10s.; S.A.A. defective cups and cases, £47 10s.; S.A.A. cut-offs and trimmings, £45 10s.; S.A.A. turnings (baled), £36; Q.F. webbing, £49; defective Q.F. cups and cases, £49; Q.F. cut-offs, £47 10s.; Q.F. turnings, £38; other "70/30" process and manufacturing scrap, £46 10s.; process and manufacturing scrap containing over 62 per cent. and up to 68 per cent. copper, £43 10s.; process and manufacturing scrap containing 58 per cent. and up to 62 per cent. copper, £38 10s.; 85/15 gilding metal webbing, £52 10s.; 85/15 gilding defective cups and envelopes before filling, £50 10s.; cap metal webbing, £54 10s.; 90/10 gilding webbing, £53 10s.; 90/10 gilding defective cups and envelopes before filling, £51 10s.

Cupro Nickel.—80/20 cupro nickel webbing, £75 10s.; 80/20 cupro nickel defective cups and envelopes before filling, £70 10s.

Nickel Silver.—Process and manufacturing scrap: 10 per cent. nickel, £50; 15 per cent. nickel, £56; 18 per cent. nickel, £60; 20 per cent. nickel, £63.

Copper.—Sheet cuttings and webbing untinned, £54; shell band plate scrap, £56 10s.; copper turnings (including shell band turnings), £44.